The right tree at the right place: Exploring urban foresters' perceptions of assisted colonization

by

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A thesis
presented to the University of Waterloo
in fulfilment of the
thesis requirement for the degree of
Master of Environmental Studies
in
Environment and Resource Studies

Waterloo, Ontario, Canada, 2014

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Urban forests feature harsh growing conditions for trees. Urban trees are surrounded by heavy anthropogenic disturbances, they often have low genetic diversity, and it is difficult for managers to maintain them because of the fragmented ownership within cities. Climate change is now expected to worsen current ecological stressors. Extreme weather events, as well as pest and disease outbreaks, will likely become more frequent, and as the climate becomes warmer, populations and species will see their habitat shift to the north. Trees are long-lived species, and their ability to adapt or migrate can be challenged by rapid climate change. To sustain ecosystem services and forest biodiversity, and to rescue vulnerable species, urban foresters might resort to assisted colonization. With this strategy, species or populations are moved northward so they can establish in their new suitable climate. Assisted colonization is controversial because it entails many ecological risks and uncertainties, and appears to go against traditional conservation values of nature restoration and preservation.

This thesis seeks to address a gap in our understanding of the perspectives and attitudes of urban foresters towards assisted colonization and related climate change adaptation strategies. I conducted semi-structured, open-ended interviews with 18 urban foresters from various forestry-related organizations in southern Ontario. I used a grounded approach for coding, letting the data guide the themes and codes rather than using predetermined ones. After going through my data a few times and developing codes, I then let concepts from the literature guide my coding to further refine the codes.

I found that while urban foresters are generally open to constrained use of assisted colonization, it is not officially part of their ongoing management strategies. Respondents believe there need to be tree species trials and experiments, as well as comprehensive inventories and monitoring of the

urban forest, but few were engaged in such programs. The findings show that ongoing efforts of such programs are small-scale and scattered across municipalities and organizations. I also found that respondents were planting southern tree species at the northern edge of their range, unknowingly implementing assisted population expansion, a variant of assisted colonization. For plantings in naturalized areas, respondents still strongly prioritize native species in their selection. In the short term, this suggests that assisted colonization is more likely to be used as a means to provide ecosystem services when native species fail to fulfill this role.

Going forward with assisted migration will require increased community involvement and partnerships, and the fragmented ownership that characterizes urban forests might complicate assisted colonization initiatives. To overcome the prevailing uncertainties that act as an impediment to the implementation of assisted colonization, higher levels of governance will have to provide leadership and guidance. Institutional structures that facilitate collaboration and knowledge sharing will also be essential to promote communication and to allow the exchange of information about both existing trials and experiments and new ones.

Acknowledgements

I would like to thank my supervisor Brendon Larson for his ongoing support and his guidance throughout every step of my Master's.

I acknowledge research support through a SSHRC Standard Research Grant and an Early Researcher Award from the Ontario Ministry of Research and Innovation (B. Larson). I am extremely thankful to the participants of this study for their time.

I would also like to thank Nicole Klenk, for her insight and her contributions to this thesis, and John Lewis, for comments and suggestions during my examination.

Special thanks to Clément, Lorraine, Philippe, Frédérique and George for their help and their encouragements.

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Chapter 1. Introduction

The world is becoming increasingly urbanized, and urban growth is set to continue at an unprecedented rate. In Canada, 80% of the population now resides in urban areas (Statistics Canada, 2011). There has consequently been a growing interest in urban studies that focus on the social and ecological components of urban environments. Urban forestry, for example, is a relatively new field of study and a profession focused on the care and management of urban forests (Konijnendijk et al., 2006). What is defined as an urban forest includes all trees, shrubs, flora and fauna along streets and boulevards and in ravines, watersheds and parks. Trees are a defining component of urban forests, and they significantly improve the well-being of urban dwellers (Pickett et al., 2001; Pickett et al., 2011). They provide a wide range of social, economic and ecological services that benefit citizens (Bolund & Hunhammar, 1999; Conway & Urbani, 2007; Pickett et al., 2011). Examples of these services include aesthetics, recreational activities, increase in property value, filtration of storm water runoffs and air pollution, and provision of food and habitat to wildlife. Although some of the less tangible services are difficult to evaluate, the value of quantified benefits can be worth millions of dollars. In Toronto, the value of trees for removing air pollution, saving energy (by providing shade), and sequestering carbon is more than 28 million dollars each year (Toronto, 2012). In short, urban forests are highly valuable and a key component of urban environments, but with climate change it could become increasingly difficult to sustain those services.

The urban landscape is characterized by a high density of people and their infrastructure, often resulting in harsh growing conditions for trees (Konijnendijk et al., 2006). Those conditions

include the urban heat island effect[1], altered soil and air quality, low genetic diversity and heavy anthropogenic disturbances (Pickett et al., 2001; Toronto, 2012). Rapid climate change is now expected to act as a compounding factor, with changes in temperatures and precipitation patterns causing considerable stress to urban forests. Trees will become more vulnerable to threats such as increasing extreme weather events and pests and diseases outbreaks. Changes in the phenology and the distribution of species are also expected, disrupting complex interactions between species and shifting their habitat northward (Yang, 2009; Aubin et al., 2011). Trees are long-lived species, so their ability to migrate can be challenged by rapid climate change. The evolution and the migration of trees are slow processes, so tree populations are generally highly adapted to local conditions and ill-suited to abrupt changes (Pedlar et al., 2011; Williams & Dumroese, 2013). In addition, urban environments are made of highly fragmented habitats, further inhibiting the movement of tree species and reducing their capacity to migrate (Woodall et al., 2010). In consequence, certain species will become maladapted and local populations could go extinct, affecting the overall health of the urban forest, and thus the benefits that derive from it. Resource managers must ensure that the urban forest can still provide those important services to citizens, and help preserve wildlife and biodiversity. To do so, it might be necessary to integrate populations and species from the south, or to assist their northward movement if they are at risk.

Assisted colonization is an adaptation[2] strategy that has been proposed as a conservation tool. It consists of moving species out of their native range with the intention of preserving them or preserving certain ecosystem services and functions (Aubin et al., 2011; Hewitt et al., 2011;

[1] The warming effect created by the built infrastructure, which absorbs heat and raise the ambient temperature in urban settings (Oke, T.R. 1982).

[2] The definition of adaptation for this research is taken from a document developed by the Clean Air Partnership in collaboration with the city of Toronto, where "Adapting to climate change means taking measures to reduce the vulnerability of a system or sector to the expected impacts of climate change (Clean Air Partnership, 2007, p.9).

Schwartz et al., 2012). In urban forestry, populations of southern tree species (e.g. from the United States) could be moved at the northern edge of their distribution or beyond it in order to maintain canopy cover and forest health. Similarly, rare or threatened species could be translocated to more northern latitudes where they can establish and thrive in a suitable climate found there in the future (Larson & Palmer, 2013). In Ontario, documents from government and non-governmental organizations demonstrate that assisted colonization is indeed being considered. In many of those documents, trials and experiments are suggested to assess how southern species grow in northern latitudes, and they sometimes explicitly refer to assisted colonization as a potential strategy to assist the migration of trees (Clean Air Partnership, 2007; Columbus et al., 2008; Trees Ontario, n.d). This being said, assisted colonization should not be seen as a cure-all to help forests adapt to climate change, as it raises multiple ecological, economic and ethical concerns (Park & Talbot, 2012).

Ecological risks and uncertainties have made assisted colonization a strategy that has been highly debated in the literature thus far (Minteer & Collins, 2010; Hewitt et al., 2011). Scientists cannot accurately predict future climates and how ecosystems will be impacted. For instance, there is a potential for negative impacts on the receiving habitat, in particular the risks of invasiveness (Ricciardi & Simberloff, 2009; Winder et al., 2011). Ethical and moral objections have also been raised, and have contributed to the divide in the scientific community (Sandler, 2009). Assisted colonization is an adaptation strategy that strays from traditional conservation values and practices, and where humans have the potential to design novel ecosystems based on their needs and interests (Sandler, 2013).

To facilitate decision making on whether we should move forward with assisted colonization, several scholars recommend including a wide range of stakeholders (Hewitt et al., 2011; Aubin et

al., 2011). I propose to add the voice of urban foresters as key stakeholders in the ongoing debate about assisted colonization for the following three reasons. To sustain the productivity of timber products, the forestry industry across the country is already setting up trials and changing seed zone guidelines in preparation for assisted colonization (Pedlar et al., 2012). In the field of urban forestry, I am not sure if or how professionals are adapting their planting practices, and little research has been done about the climate change impacts on urban trees (Yang, 2009). Moreover, while urban foresters are encouraged to proceed with their own trials and experiments with southern seed sources and species, they also recommend prioritizing native species in their plantings (Ordóñez & Duinker, 2013). The contrasting positions of planting locally adapted versus species from southern sources further raises questions on urban foresters' tree planting strategies in regards of adaptation. Lastly, cities are currently experiencing many of the listed climate change impacts. With the urban heat island effect, a high number of exotic species and being altogether severely altered ecosystems, they represent an ideal ground for climate change and adaptation research (Pickett et al., 2001; Francis et al., 2012). Urban foresters are in charge of trees, the foundation of the urban green infrastructure, and have undoubtedly a major role to play in adaptation to climate change.

I argue that knowing if urban forest professionals integrate climate change to their planning and management will contribute to the well-being of an increasingly urbanized population, and to helping the urban forest cope with the stresses. This information can allow management to be adapted to promote forest resilience and maintain the provision of services delivered. The research question motivating this thesis is: How are urban forest stakeholders of southern Ontario thinking of adaptation strategies such as assisted colonization in urban forest planning and management?

The next chapter presents an in-depth review on assisted colonization and urban forestry. I proceed to explain how assisted colonization pertains to urban forestry, and why it is important to explore how urban foresters are adapting their planting practices in view of climate change. Chapter three lays out the methods that were used to conduct the research, from the methodological framework to the coding and analysis of the data. In the following chapter, I present the results, explaining the main themes and providing interview excerpts to highlight findings. In the next chapter, I discuss the implications of the results, providing an interpretation of the data and links to the literature. I follow with some recommendations in the light of my findings, and I then finish with a concluding comment.

Chapter 2. Reviewing assisted colonization and urban forestry

Assisted colonization is considered a potential strategy to protect endangered species and to sustain ecosystem services and functions in the face of climate change. The ecological and moral implications of this strategy are contentious, although it is already being implemented in the forestry industry to maintain commercial productivity. So far, it is not known whether assisted colonization is being applied in the urban forestry sector or not. The following chapter explains how assisted colonization pertains to urban forestry. The first section describes the impacts of climate change on biodiversity, and what makes assisted colonization a potential option to help alleviate these impacts for vulnerable species. The technical and ethical challenges of assisted colonization are then discussed, followed by a brief section about current applications of this strategy in the Canadian forestry sector. The rest of the chapter examines my motivations behind the research on urban foresters in southern Ontario and how they evaluate assisted colonization and its implementation in the urban forest sector.

2.1. Climate change impacts on biodiversity

Scientists of the Intergovernmental Panel on Climate Change (IPCC) have now deemed that the warming of the global climate is unequivocal. Indeed, global average surface temperatures have noticeably increased, and model projections suggest the increase should be steady in the upcoming decades (IPCC, 2013). Human activity is mainly responsible for the observed alterations in the climate system, in particular from fossil fuel emissions and land use change (IPCC, 2013). Changes in precipitation trends are already occurring, and global precipitation patterns will continue to undergo significant changes. In their Fifth Assessment Report (AR5), the IPCC documented a warmer atmosphere and oceans, with less snow and ice, higher sea levels, and increased concentrations of greenhouse gases (IPCC, 2013). The impacts of these environmental changes

will vary according to geography and to available resources to mitigate and adapt (Chen, 2011). Climate change is nonetheless expected to dramatically alter global biodiversity and ecosystems.

Perhaps one of the biggest concerns with current changes and projected climate scenarios is how fast they are occurring. Indeed, scientists have shown that the pace of projected change is unprecedented over past centuries and millennia (IPCC, 2013). The Northern Hemisphere manifests the greater warming with an average temperature increase of 3.2^{o}C, leading to longer growing seasons (Parmesan, 2006; Environment Canada, 2014). In Canada, records indicate that from 1948 to 2013, annual temperatures have warmed by 1.6^{o}C (Environment Canada, 2014). The pace of change is challenging the ability of species to adapt in response to the climate-driven impacts on ecosystems (Lawler, 2009).

Biologists are already observing changes in the phenology and distribution of plant and animal species, which can disrupt the synchronicity of food, habitat and other essential coordinated interactions between species (Parmesan, 2006). The disturbances to species interactions have the potential to alter ecosystem functioning and to threaten the survival of certain species—and in particular, specialist species (Loss et al., 2010; Ste-Marie et al., 2011). Moreover, habitats will shrink significantly for a number of species. The climate within their current range will no longer be suitable, eventually forcing them to move northward in latitude or upward in elevation (Lawler, 2009; Minteer & Collins, 2010; Schwartz et al., 2012). Altogether, Canadian agencies have reported declines in abundance of some species, changes in the ranges of others, and changes in timing of their breeding and movement patterns (Federal, Provincial and Territorial Governments of Canada, 2010).

2.2. Climate change impacts on North American forests

The response to climate change will vary from one species to another; certain species will be more affected than others. Although in some cases species will adapt, the evidence does not suggest it could alleviate species extinction (Parmesan, 2006). Trees represent a particular concern because of their slow migratory rates and long life cycles. There will be inevitable time lags from dispersal to maturation of tree species, and this will affect in turn forest growth and composition (McKenney et al., 2009; Aubin et al., 2011; Williams & Dumroese, 2013). The average migration speed for trees is 50km per century, so at that rate they would migrate only 25km in the next 50 years whereas under a 2 ^{o}C increase in mean annual temperature they would need to migrate on the order of 300 km northward (Aubin et al., 2011). Indeed, there is already evidence that the northward migration of North American trees is failing to keep pace with climate change (Zhu et al., 2012). In cases where trees and plant species will not keep pace with the changes, a loss of forest health and productivity might result (Leech et al., 2011; Ste-Marie et al., 2011).

In addition, pollution, habitat destruction and fragmentation like dams, roads, urban and residential areas and agricultural surface are jeopardizing the chances of trees to migrate to their new, suitable habitat (Millar et al., 2007; Lawler, 2009; Vitt et al., 2010). Notably, in some cases, the warmer climate and increased carbon dioxide concentration could result in increased tree growth, though this may be limited by new threats related to the changing climate (Aubin et al., 2011). Indeed, trees respond to complex interacting factors. Depending on the region of study, trees can manifest both increased growth and northward shifts of treelines in response to climate change (Parmesan, 2006).

The survival of trees is challenged by biotic and abiotic stresses, which include weather events and insects. The impacts of these stresses are already being observed in Canada's forests, evidenced

by increased frequency and severity of droughts, wildfires, and pest and disease outbreaks (McKenney et al., 2009; Ste-Marie et al., 2011). In British Columbia, for example, the devastating mountain pine beetle epidemic has been attributed to warmer winter (Leech et al., 2011). Future climate projections suggest that the resulting changes could cause significant ecosystem reorganization and put certain trees species at risk.

Different climate change mitigation scenarios are possible for the future, with different climate outcomes, but irreversible changes will nonetheless occur. We must now contemplate adaptation strategies to respond to the climate-induced threat to biodiversity (Millar et al., 2007). In the face of these challenges, scientists and practitioners have been weighing options in resource and land management practices to fit this new reality. Among the proposed novel conservation strategies, assisted colonization has been the subject of a heated debate lately in the academic literature (Hewitt et al., 2011).

2.3 Defining assisted colonization

Assisted colonization[3] (AC) is an adaptation strategy proposed in the field of conservation biology. Schwartz et al. (2012, p. 733) define it as "…the intentional act of moving species, populations, or genotypes (the *target*) to a location outside a target's known historical distribution for the purpose of maintaining biological diversity or ecosystem functioning as an adaptation strategy for climate change." For issues of clarity between the different motivations leading to AC, I follow Pedlar et al. (2012) and distinguish two types of AC, *species rescue* AC and *forestry* AC. The former is specifically intended to rescue endangered species, while the latter is used to maintain forest productivity and certain ecosystem functions and services. In both cases, a species is moved either

[3] Assisted colonization can also be referred to as assisted migration and managed relocation. For further information, see Hällfors et al., 2014.

northward in latitude or upward in elevation, in an attempt to mimic the natural migration route as the climate warms up. The scale of AC can differ from one case to another. For instance, translocations could vary from the limit of the species' range to a transcontinental translocation. In the same way, the candidate species can range from plants to megafauna (Aubin et al., 2011).

There are three distinct applications of AC, in regard to the scale of range expansion (Leech et al., 2011; Ste-Marie et al., 2011). *Assisted population expansion* refers to the movement of populations within a species' range; *assisted range expansion* refers to the movement of populations near the proximity of a species' range, where the current climate is expected to shift; and finally, *translocation of exotics* is the movement of species well outside of their historical range (Leech et al., 2011; Ste-Marie et al., 2011). Although moving species around is nothing new, AC differs from past species introduction mainly in terms of its focus on anthropogenic climate-driven extinctions. Moving species because of their vulnerability to human induced climate change is new, but also nowadays the movement of species is under tighter regulation, unlike previous norms in the past (Vitt et al., 2010; Aubin et al., 2011; Ste-Marie et al., 2011). However, scientists have not reached a consensus on whether to strategically move species in response to climate change.

Proponents and opponents of AC have different views of the trade-offs behind this strategy. For opponents, the risks and uncertainties involved with AC outweigh most of the benefits resulting from the translocation (Ricciardi & Simberloff, 2008; Sandler, 2009; Sandler, 2013). Proponents argue that in a future where biodiversity is more threatened than ever, AC will become an essential tool for biodiversity conservation in an era of rapid climate change (Lawler & Olden, 2011). The high levels of risk and the uncertainty associated with AC have the potential to create important negative ecological, economic and social consequences, as some scientists argue. On the other hand, some scientists in favour of AC argue that losing a species is a negative consequence in

itself. They claim that careful assessment and management can alleviate some of the risks and uncertainties, and make it a promising option (Minteer & Collins, 2010; Hewitt et al., 2011; Aubin et al., 2011; Schwartz et al., 2012). Regardless of the different stance on the feasibility and the motivations behind AC, managers are faced with the technical and ethical issues of implementing AC, which I turn to now.

2.4. Technical questions related to AC

There are ecological concerns and challenges with the implementation of AC. First, there is the possibility that the translocated species will become invasive. It is difficult to predict the probability of invasion, however, because scientists can only provide estimates (Hunter, 2007; Lawler, 2009; Lawler & Olden, 2011). Second, for a successful translocation, there needs to be an understanding of how ecosystems will change, and which habitat will be suitable for the candidate species. Models and scenarios make climate projections possible and allow scientists to broadly assess how and where the climate will change, but these projections are still relatively uncertain (Lawler, 2009; Millar et al., 2007). Third, when considering the receiving site (the area where the species is moved), issues such as the potential level of disturbance caused by the translocation require careful consideration, because there is a risk of disrupting historical evolutionary and ecological processes (Minteer & Collins, 2010; Sandler, 2013). It is, again, difficult to make accurate predictions on how the translocated species will impact the receiving ecosystem. Fourth, there is always the possibility that the translocated species will not thrive in its new location and fail at establishing permanently (Minteer & Collins, 2010). It is important to note that the further distance species are moved, the more likely they will have a negative impact. Generally, concerns increase with the distance of the translocation: moving species across great distances, as it is the

case with transcontinental AC, entails more risks and uncertainties, and will therefore encounter more resistance for its application (Minteer & Collins, 2010; Aubin et al., 2011).

There are also concerns about the long-term impacts of AC on population genetics. For instance, AC may lead to hybridization between the new species and the ones there previously, resulting in genetic contamination (Aitken et al., 2008; Pedlar et al., 2011). Alternatively, maladapted genotypes or pathogens may be introduced into the receiving ecosystem (Minteer & Collins, 2010; Ste-Marie, 2011; Pedlar et al., 2011). Even the donor system could be negatively impacted by the translocation from the removing of species or seeds, further contributing to weakening the population (Aubin et al., 2011). On the other side, we know that ecosystems will be transformed by the changing climate. Some ecosystems will undergo important restructuring, and it is difficult to predict the amount of change. Thus, worrying about the introduction of a particular species might become a lesser concern (Lawler & Olden, 2011).

Financial issues will also be a challenge when considering AC (Hunter, 2007). The resources available for translocations may be limited, and it is uncertain who will be in charge of covering the cost of the process, from planning to monitoring. Additionally, the long time frame of such an operation will require institutional flexibility. The time delay of ecosystem response to climate change and to the implementation of AC complicates monitoring operations (Aubin et al., 2011). With trees in particular, for resource managers to get meaningful results from the translocations could take several years.

The ethical and value-laden considerations of the debate further complicate it, because one's desired outcomes and perspective on nature will influence one's position toward AC (Minteer & Collins, 2010; Aubin et al., 2011). These various attitudes and positions include (but are not limited

to) ones values (e.g., instrumental versus intrinsic) and whether one adopts an ecosystem-based or species-based approach.

2.5. Ethical questions related to assisted colonization

Many academics have brought up crucial questions related to the decisions society will have to make under climate change (Aubin et al., 2011; Lawler & Olden, 2011). Is the idea of wilderness and pristine nature obsolete? Is nature inherently valuable (Sandler, 2009)? The answers to these questions will determine how much we will intervene in ecosystem management, and consequently shape our future ecological systems. In other words, it will determine what nature is to us and where we fit within it (Ste-Marie et al., 2011). How do we want ecosystems to function, what services do we want to obtain from them, and what should have priority? A possible answer would be to let ecosystems and community of species re-organize themselves, to let nature 'be'. Those grand questions are rooted in the ethical dilemmas that have been amply discussed in the literature.

The motivations behind the choice of candidate species and the translocations are key ethical challenges in the AC dialogue. As Aubin et al. (2011) point out, the debate surrounding AC involves scientific, social, political and economic dimensions. A variety of stakeholders will be involved in decision-making, and they will hold a variety of values and thus favour different objectives. Aubin et al (2011) argue that ultimately, perceptions regarding AC are shaped by personal values and beliefs, which in turn influence the intended outcome (Aubin et al., 2011). In urban areas where land use is disputed by many stakeholders, development projects often compete with conservation interests. A case study in Toronto, for example, has demonstrated that science-based evidence was not a determinant in the final land planning decision (Martin et al., 2014). This contributes to the idea that ultimately, the conflictual value-laden dimensions of AC will not be

resolved by scientific knowledge and technical expertise, but by weighing different community members' perspectives in the decision-making process.

Some scientists have argued that AC is not a solution, because it does not address the core ethical, economic and political problems that are driving climate change. In this view, AC appears to be a way to avoid making real changes by diverting attention from ways to mitigate climate change (Minteer & Collins, 2010; Park & Talbot, 2012). Those who hold that position continue to advocate the use of traditional conservations tools and goals, arguing that novel ecosystems and AC are strategies that are too interventionist and too focused on adaptation rather than mitigation. Yet, Minteer & Collins (2010) argue that at this point, climate change needs to be addressed with both adaptation and mitigation approaches. They also suggest that AC could help bring into light the pressing issues surrounding climate change, resulting in increased attention from the public eye and mainstream media. The public and political awareness gained from these AC initiatives with charismatic species could facilitate mitigation policy-making (Minteer & Collins, 2010).

Still, as time goes on, the set of options available to managers and decision-makers for saving endangered species is decreasing. Although not an ideal option in every case, AC might become an essential tool for the sake of biodiversity in a rapid changing climate regime. In fact, motivated by commercial interests, a form of AC is already being implemented in the forestry industry.

2.6. Forestry assisted colonization

As mentioned previously, climate change maladaptation is a particular concern for the Canadian forest sector (Johnston & Hesseln, 2012; Aubin et al., 2011; Ste-Marie et al., 2011). Trees are long-lived species and their maladaptation can last for decades if future climate is not taken into consideration. Climate impacts on tree growth and forest composition are inevitable, although

variable according to the spatial location. Scientists recommend that seed transfer guidelines and relevant policies must be reviewed in all of Canada's jurisdictions (Vitt et al., 2010). British Columbia has extensive ongoing trials of AC forestry, and Québec along with Alberta are changing their seedlings policies in preparation for AC applications. Other jurisdictions are getting ready for future AC as well, by collecting information and setting up decision-making tools (Pedlar et al., 2011; Pedlar et al., 2012). Unlike species rescue AC, which remains open to debate, in the literature AC forestry has been deemed a key strategy to respond to climate change in the forest sector (Pedlar et al., 2012; Williams & Dumroese, 2013).

Indeed, the implementation of AC in Canada's forests has not come across significant controversy so far. This can be mainly explained by the specifics of forestry AC, which remove several risks and uncertainties and makes its implementation more likely, while the application of species rescue AC remains for most part theoretical (Vitt et al., 2010; Pedlar et al., 2012). With forestry AC, the potential for creating invasive species and to introduce diseases to the new populations or to the other species is limited, because the translocation is often within the current range of the species or within moderate range extensions (Aubin et al., 2011; Park & Talbot, 2012; Pedlar et al., 2012). Populations of trees have developed traits specifically adapted to their local climate. In the case of forestry AC operations, it is often a matter of changing the seed source so it matches anticipated future climate, and can also be referred to assisted population expansion (Leech et al., 2011).

2.7. Moving forward with assisted colonization

Even though forestry AC is already being implemented, certain concerns remain since according to Aubin (2011), AC could open the door to a broader set of goals, and an open debate for environmental decision and policy-making needs to take place regarding desired outcomes. Radical approaches have been discussed, such as novel anthropogenic ecosystems as a

management goal (Aubin et al., 2011). A novel ecosystem features heavy anthropogenic influences on biotic and abiotic components. The major biotic influence often comes from the introduction of species and the decline or extinction of local populations (Hobbs et al., 2006). Interestingly, cities feature both of these characteristics. Thus, new management approaches (e.g. AC) may not seem as radical since urban environments are already fundamentally altered. However, as Pedlar (2012) warns, if forestry AC succeeds in meeting management goals, stakeholders could perceive it as a "cure-all" for forests affected by climate change.

To help move towards a greater consensus on the overall AC debate, the literature has been clear about the need to integrate more actors to the ongoing dialogue, in part because a better understanding of the values and beliefs that community members bring to their interpretation of AC is required at this stage (Minteer & Collins, 2010; Aubin et al., 2011; Lawler & Olden, 2011). According to Aubin et al. (2011), further research assessing the attitudes of forest managers towards conservation and forestry AC is needed because they bring "a key perspective" (p. 762). As a step towards achieving this goal, I propose to examine the perspectives held by urban forest stakeholders.

2.8. Definition and structure of the urban forest

Urban areas are expected to grow considerably as the global population increases (UNFPA, 2007). In Canada, the 2006 census revealed that 80% of Canadians currently live in urban areas (Statistics Canada, 2011). Although more people now live in cities than in rural areas, urban environments have been overlooked in certain fields of research, but are now gaining more attention and research efforts (Konijnendijk et al., 2006). It has become evident that urban areas are impacting not only immediate surroundings but even distant hinterlands and the entire biosphere. Urban research has

raised important considerations in the past decades, and municipalities are now seeking to include urban ecology in management and planning (Pickett et al., 2011).

There are many definitions of what constitutes an "urban forest", and they mainly differ in their complexity. The Canadian Urban Forest Strategy 2013-2018 defines the urban forest as "trees, forests, greenspace and related abiotic, biotic and cultural components in areas extending from the urban core to the urban-rural fringe" (CUFN, 2012, p.3). Therefore, the urban forest is made up of many subsystems, but it altogether includes all trees, whether located along streets or within woodlots, parks, wetlands or residential backyards, as well as other vegetation (such as shrubs and lawns) and their habitat (Bolund & Hunhammar, 1999; Toronto, 2012). For issues of scope and feasibility, the research focus is on the tree components of the urban forest. Trees are also a founding component of the urban forest, and of particular interest for research about AC as previously explained.

Trees are a key component of urban social-ecological system. While the economic, social and ecological services provided by urban forests are getting more attention, they have historically been ignored in development decisions (Konijnendijk et al., 2006). Nowadays, the value of trees in the urban landscape still needs increased recognition, as demonstrated by the challenge of making tree conservation an issue for stakeholders (Konijnendijk et al., 2006; Martin et al., 2014). Certain municipalities decide to adopt (and implement) an urban forest management plan (UFMP) in an effort to maintain/expand the urban forest and obtain the most benefits from the services provided. Indeed, the composition and abundance of the urban forest result from a combination of biophysical factors, but also social, political and economic factors (Conway & Urbani, 2007; Kowarik, 2011). Although it is true that a variety of social determinants (e.g. neighborhood income and education level, age of housing stock) shape the local urban forest, the policy and management

decisions for sustaining and expanding the urban forest remain a major determinant (Conway & Urbani, 2007; Pickett et al., 2011). A critical component that characterizes the urban forest and can constrain efforts directed to maintain and expand it is the high percentage of canopy cover located on private lands. This represents a challenge for concerted policies and planting activities to revitalize the urban forest (Barker & Kenney, 2012). Nevertheless, trees located on either private or public properties ultimately benefit the community at large.

The wide range of services delivered by the urban forest benefit the whole community by fulfilling multiple functions (Gómez-Baggethun & Barton, 2012). First, trees contribute to storm water runoff treatment by intercepting rainwater, which then evaporates or soaks into the ground. The ground filters and removes pollutants from the water before it enters waterways, reducing the costs of water treatment and storage. Second, trees provide shade and cooling, alleviating the urban heat island effect and reducing energy costs. They also clean the air by removing many air pollutants, therefore contributing to the overall air quality in the city and mitigating climate change by storing atmospheric carbon. The urban forest provides habitat for the city's wildlife, serving as food, cover, breeding and nesting. In the city of Toronto, it has been estimated that the ecological services of trees in terms of air pollution removal, energy savings and carbon sequestration alone are worth more than 28 million dollars annually (Toronto, 2012). Other economic and social benefits include the protection of grey infrastructure (sidewalks, buildings), higher property value, pleasing aesthetics, improved quality of life for residents, promotion of physical activity and relaxation, and more (Bolund & Hunhammar, 199; Conway & Urbani, 2007; Pickett et al., 2011).

Urban forests may vary from one to another in composition and structure, but they nevertheless hold common characteristics due to the distinct features of the urban landscape. Two of the main characteristics of urban ecosystems are the high density of human inhabitants and the high density

of the built infrastructure (Pickett et al., 2001). The urban environment is further characterized by higher temperatures caused by the urban heat island effect, altered soil, low genetic diversity and a high proportion of exotic species (Pickett et al., 2001; CUFN, 2012). More often than not, urban trees grow in stressful environments, and climate change exacerbates those stressors. However, the harsh living conditions and the history of planting non-native species for amenities make urban areas particularly interesting for research. Indeed, an important feature of the urban area is that it manifests some of the major projected conditions of global climate change: increased temperatures, altered precipitation patterns and drying of soils (Pickett et al., 2001; Francis et al., 2012). Along with the heavy anthropogenic influence on the composition of ecosystems, cities are therefore an environment where we can assess the effects of climate change on biodiversity and experiment with novel assemblages of native and exotic species (Pickett et al., 2001; Dearborn & Kark, 2010). Francis et al. (2012) have raised research needs and the opportunity that urban environments represent for climate change induced biodiversity shifts: "These are not necessarily second-rate ecosystems compared with those that are more 'natural', but perhaps offer our best chance at observing the dynamics of novel ecosystems…" (p.188).

2.9. Assisted colonization in southern Ontario's urban forests

Concerns with climate change impacts are two-fold: the uncertainty of how climate will vary according to the emission scenario that will prevail, and the uncertainty on how systems will respond to the changes. In a case study conducted in Philadelphia and based on two possible scenarios, Yang (2009) found that despite projected climate change impacts, urban foresters could keep planting the same tree species that are currently growing in the city. Additionally, the warmer climate would broaden the choice of available species for planting (Yang, 2009). Similarly, the findings of a recent study in the Clay Belt Region of Ontario suggest that assisting the movement

of seeds for plant species may not be necessary until mid-century (Parker et al., 2012). Although this could seem promising for urban forestry in Ontario, urban foresters need to conduct their own research and monitor the current response of species to climate change. In proposed frameworks, monitoring has been deemed a necessary step before undertaking AC, as well as for ongoing AC efforts (McLachlan et al., 2007; Schwartz et al., 2012). Climate change impacts are experienced locally under ecological and social contexts that vary spatially, and local stakeholders play a critical role in addressing those impacts (Measham et al., 2011).

In another study, Woodall et al. (2010) argue that the trees already established at higher latitudes than their historical range could serve as a seed source for future migration. However, the authors also specify that the potential for urban areas to facilitate the migration of trees is constrained by a number of factors. Although they bring up interesting points about the ecological dimensions of urban assisted migration, the social and political dimensions involved in the planning and management of the urban forest are absent from their research. It must also be remembered that AC in urban forestry could be used not only to plant southern seed sources further north for forest productivity, but also for species rescue.

As a conservation tool, one of the goals of AC is to protect or enhance biodiversity, and to therefore increase the resilience of urban systems. AC could eventually play a key role in retaining some species around urbanized areas. For instance, certain area-sensitive species of bird are threatened by the loss of forest cover and the fragmentation of their habitat in urban settings, and climate change has the potential to make the lack of suitable habitat worse for these species (Savard et al., 2000; Environment Canada, 2006). If key native tree species become maladapted, assisting the migration of southern tree species to fulfill ecosystem services and functions left vacant could potentially retain those area-sensitive bird species. Moreover, restoring and enhancing the urban

forest will also benefit urban-tolerant bird species. An increase in the populations of some birds in adjacent forested areas has been noticed when urban areas contain forest canopy (Environment Canada, 2006). The provision of shelter or food for birds or even mammals and other vertebrates is an example of ecosystem functions that contributes to enhancing biodiversity (Savard et al., 2000). By assisting the migration of southern trees species that are expected to thrive in southern Ontario's climate, managers can also contribute to increasing the canopy cover or enabling wildlife corridors, which is essential for protecting and enhancing biodiversity. As with other social ecological systems, an urban area that has higher levels of biodiversity is more resilient to heavy disturbances (Walker & Salt, 2006). The more tree diversity, the better the urban forest can withstand overall damage and sustain its canopy cover. The ongoing outbreak of Emerald ash borer, and past examples like Dutch elm disease, have taught this lesson to urban foresters at a great price (Alvey, 2006; Park & Talbot, 2012; Steenberg et al., 2013).

Protecting and enhancing biodiversity in urban areas is key to the social and mental health of humans (Kowarik, 2011). In an increasingly urbanized world, human/nature interactions and relationships will be shaped by the city's green landscape and fauna (Kowarik, 2011). By 2030, about five billion people are expected to live in cities (UNFPA, 2007). Thus, an increasing number of people will obtain their understanding of the natural world in cities, from the urban environment they live with. For instance, butterflies and songbirds are elements of the urban wildlife, and their presence is important for nature-related activities such as observing and photographing. Contact with nature in the urban environment is critical because it has been shown that everyday life exposure to nature increases sensitivity to environmental issues (Miller, 2005).

Assisted colonization might be used to retain or enhance biodiversity in urban areas. Dearborn & Kark (2010) suggest that biodiversity takes a different meaning according to the desired goal: for

instance, an area with a high proportion of exotic species might be recommended if the goal is to maximize the exposure of citizens to different species. In regards of biodiversity, and in the case of tree species and the wildlife they sustain, Savard et al (2000) argue that not all species should be considered equally. Urban managers and planners should consider desirable species in terms of size, shape, abundance, distribution, function, and desirability. The choice of tree species will provide different services, for instance planting conifers or fruit trees provide services of food for wildlife and for humans, respectively. Urban foresters thus need to adapt their management practices according to the desired goals.

Maintaining the provision of ecosystem services is another major motivation for urban biodiversity conservation. Dearborn & Kark (2010) argue that "even small green spaces can provide high impact ecosystem services (p.435)." They further argue that maintaining native species as the main goal of conservation is not realistic in urban areas, and rather questions about what service or function, and to which purpose, should determine the species assemblages. With this in mind, resorting to AC might be necessary in an uncertain ecological future. Because urban foresters must deal with the changing climate impacts and forest fragmentation, documents aimed at resource managers now recommend adaptation strategies, and demonstrate that AC is indeed considered as an option (Clean Air Partnership, 2007; OCCAR, n.d.).

As shown by their urban canopy plans, the city of Toronto and other municipalities from southern Ontario (e.g., Kingston) are considering adaptation measures to respond to climate change (Kingston, 2011; Ordóñez & Duinker, 2013). There are also several documents that were put together by different levels of government and environmental non-government organizations (ENGOs), sometimes mentioning AC as a potential strategy. For instance, the city of Toronto in collaboration with the Clear Air Partnership published the Climate Change Adaptation Strategy in

2007 (The Clean Air Partnership, 2007). It considers the northward migration of plant species and the increase in southern species in the Toronto regions, suggesting experiments with plantings to avert the loss of biodiversity and canopy cover. Among the proposed adaptation measures, the report recommends tree health monitoring, watering programs and changes in plantings, in which there is mention of "tree planting trials" to experiment with new growing conditions and to "plant new species" in cases where native species are unable to adapt. (The Clean Air Partnership, 2007, p. 17, 23).

The region of Peel also has a standalone climate change strategic plan presenting adaptation options and challenges for the city's urban forest, displaying a series of recommended actions with goals and a time frame (Region of Peel, 2011). Trees Ontario, a registered not-for-profit organization that initiated a project for planting locally adapted native tree species in Toronto (Tree Seed Diversity Project), acknowledges the effects of climate change and suggests "strategic experimentation with other sources of our native species and possibly other species" (Trees Ontario, n.d.).

On the other hand, only a handful of documents explicitly use the term AC, rather than just refer to the northward movement of southern species. The Ministry of Natural Resources (2011) dedicated an entire report to AC, and it extensively reviewed the literature in preparation for future implementation of AC forestry in Ontario. While the document does not make any recommendations in favour or not of AC, it explains why more research on tree response to climate change and on AC is necessary. The publications that implicitly or explicitly discuss AC, or at least recommend monitoring as well as risk and vulnerability assessments, are an indication that the southern part of the province is moving ahead with adaptation to climate change, and integrating strategies to their management and planning.

Table 1. Examples of documents emitted by various organizations that suggest adaptation strategies

Document Title	Level	Explicitly mentions AC
Adapting to Climate Change in Ontario: Report of the Expert Panel on Climate Change Adaptation (EPCCA, 2009)	Provincial	No
City of Toronto and Trees Ontario Tree Seed Diversity Project (Trees Ontario, n.d.)	Municipal	No
Climate Ontario: Forests and Forestry in a Changing Climate (OCCAR, n.d.)	Provincial	Yes : “Facilitating assisted migration of tree species and seed sources where data support these activities” (p.2)
Climate Change Adaptation Options for Toronto (Clean Air Partnership, 2007)	Municipal	No
Climate Ontario: Terrestrial Invasive Species: In a Changing Climate (OCCAR, n.d.)	Provincial	Yes : “Employ assisted migration techniques to maintain vulnerable native species and introduce other future climate-suitable species” (p.2)
Climate Ready: Ontario's Adaptation Strategy and Action Plan 2011-2014 (Ontario, 2011)	Provincial	Yes: “MNR will investigate assisted migration for tree species as a potential management tool” (p.57)
Managing Tree Seed in an Uncertain Climate: Conference Summary (Colombo et al., 2008)	Provincial	Yes: “A strategy of judicious assisted migration, if adopted, would allow limited, low-risk movement of species and populations” (p.3)
Vulnerability of Canada's Tree Species to Climate Change and Management Options for Adaptation (Canadian Council of Forest Ministers, 2009)	Federal	Yes: “Adaptation measures include reducing forest vulnerability through facilitated migration” (p.26)

Urban forestry is mostly cared for at the municipal scale (Conway & Urbani, 2007; Barker & Kenney, 2012; Mincey et al., 2013). Even though some UFMP take climate change into account and encourage moving towards adaptation strategies, it is not always clear how exactly they will proceed (Ordóñez & Duinker, 2013). Moreover, in many urban forestry related documents, the planting strategy focuses on native species. Planting locations and conditions vary between and within urban areas, and therefore tree species are chosen accordingly, yet the strong emphasis on native species in an era of rapid climate change can still be questioned. There is limited information on how tree populations will respond to climate change in Ontario, and there is undergoing research that will help determine the potential of AC in the province, among other goals (Ministry of Natural Resources, 2011). Still, native species might not do well in future climates, and planting strategies should be reviewed with this in mind.

Notably, to the best of my knowledge there is very little mention within relevant documents of recommendations to move populations or species at risk northward where they might be able to establish and thrive. One notable case was found in a report delivered by the Ontario Centre for Climate Impacts and Adaptation Resources (OCCIAR, 2009). AC is mentioned as an example of an adaptation strategy to help a vulnerable tree species, the Eastern Hemlock, and the author recommends "assisted migration to appropriate sites further north" (Douglas, 2012, p.29). Interestingly, in 2007 the city of Sault Ste Marie in northern Ontario hosted a conference, *Managing Tree Seed in an Uncertain Climate*, where participants were asked to prioritize and share their tree seed management needs in regards of climate change. A total of 91 needs were identified, and the need to document cases of AC and to test tree species and population adaptability in future expected climate ranked in the top five (Colombo et al., 2008). In any case, urban foresters should be proactive in their management and consider future climate when

choosing species for current urban greening projects, as today's management decisions for trees will still have an impact in decades from now on future forests (Yang, 2009; Vitt et al., 2010).

Arguably, forests located in urban environments are situated at a crossroad between forestry AC and species rescue AC. Granted that trees in natural forests and plantations and urban trees will cope with climate change impacts differently, because their growing environment and management methods differ, there is an urgent need to combine climate change and urban forestry in research (Yang, 2009).

Following this, my research question is: How are urban forest stakeholders of southern Ontario thinking of adaptation strategies such as assisted colonization in urban forest planning and management? Through this research question, this study will seek to explore how urban forest stakeholders conceptualize AC, and how this strategy is integrated within broader urban forest management and adaptation plans.

Chapter 3. Methods

This chapter will explain the methods that were used to conduct this research project. The first section outlines the methodological framework, followed by information on participant selection and location. The final section explains in detail the study design as well as the procedures for data collection and analysis.

The decision to go forward or not with AC, and on which terms, will undoubtedly have environmental, economic and societal impacts. Conflicting values and interests can be a great impediment in formulating policies. For future decision making regarding AC, as mentioned previously, the inclusion of the knowledge and the values held by a broad range of stakeholders is recommended (Hewitt et al., 2011). This study aims at exploring the perspectives and attitudes held by urban forest professionals in southern Ontario towards AC. Given this objective, I sought to interview individuals involved in the management and the planning of urban forests. While this includes a broad range of stakeholder, I focused on respondents who have a systemic approach and play a decision-making role in urban forestry. The main objective is to find out how they conceptualize AC as an adaptation strategy in urban forestry. For this research, I ask: "How are urban forest stakeholders of southern Ontario thinking of adaptation strategies such as assisted colonization in urban forest planning and management?" As secondary objectives, the research also sought to:

1. Assess southern Ontario urban foresters' knowledge of AC;
2. Determine if urban foresters are favourable (or not) towards AC;
3. Explore urban foresters' attitudes related to AC and other novel conservation tools and goals;

4. Explore the extent to which urban foresters are integrating adaptation strategies in their planning and management;
5. Provide meaningful information for future AC policy-making and for moving forward with climate change adaptation strategies in southern Ontario.

3.1. Methods

3.1.1. Qualitative inquiry

This research stems from a grounded theory perspective, which means that theory is sought through the process of analyzing the collected data (Gibbs, 2007). The main purpose is to investigate and discover the perceptions and values held by a group of stakeholders towards the object of study. The literature states that qualitative enquiries are best suited for this type of research. Indeed, qualitative methods are best used for in-depth analysis of experiences. Using various theoretical frameworks, qualitative approaches unravel the nuances and subtleties of human experiences. According to Hay (2010, p.5) qualitative researchers are best at tackling questions concerned with social structures or with individual experiences. I therefore adopted a qualitative research method to conduct this exploratory study, with in-depth interviews as the main data collection technique. I then used guiding concepts found in the literature, and reviewed and analyzed the content of the interviews. Through the final research step of analysis and interpretation, I explored and made sense of the values and meanings (Hay, 2010).

3.1.2. Study design

A qualitative research methodology was used for this research project, with semi-structured interviews as well as a review of documents in the collection and analysis of the data. The interviews are considered most appropriate for this project's research objectives. Interviews are

advised for an exploration of different point of views, as well as understanding beliefs and practices (Hay, 2010). The semi-structured interview allows the researcher to explore what is relevant to the informant, which in this case is particularly important since the general knowledge held by urban foresters towards AC is not known. The semi-structured format is also necessary because even though the respondents are all urban forest professionals, they come from different organizations and do not have the same credentials and background. Certain questions might therefore vary from one interview to another, according to each participant. This semi-structured format also allows the interviewees to share what is important for them, discuss which aspects are more relevant and speak their minds about it. The questions were formulated with the help of guiding concepts found in the literature on AC and urban forestry (McLachlan et al., 2007; Richardson et al., 2009). The interviews were transcribed and then coded.

3.1.3. Review of grey literature

The review of documents is useful to the researcher who wishes to unravel information about the studied group (Marshall & Rossman, 1995). For the purpose of this research, UFMP were reviewed, as well as climate change adaptation strategies, whenever such documents were available. I reviewed these documents to obtain information on the selected strategies to maintain and expand the urban forest, and to get a better understanding of the vision, goals and objectives of urban forest management in southern Ontario. They also were useful to determine what is suggested in terms of adaptation strategies for the urban forest sector, and if AC is a proposed conservation strategy. Documents were either issued by municipalities, provincial or federal government or by various environmental associations and organizations.

3.1.4. Formulating the questions

This section contains information that helped me develop a structured and effective questionnaire. In order to formulate the best interview questions, I tried to use a language understandable to my informant, for instance reflecting their work field and their level of experience concerning the discussed matter. It is also important for the informant to possess the knowledge to answer a question, and for instance I did not know how much they knew about AC. Fortunately, during interviews this is something the researcher can adapt the questionnaire to if necessary, and I did when necessary (de Vaus, 1995). Ambiguity of terms and of the question itself should be avoided as much as possible, and the wording is particularly important for developing clear, straightforward questions. Long questions although sometimes inevitable are not ideal, and the researcher should ask herself if the question can be shortened. Another factor to consider when formulating the interview is to pay attention to double-barreled questions, or in other words, questions that ask more than one question at once (de Vaus, 1995). In relation to my research project, an example of such a question could be: What do you think of adaptation strategies such as assisted colonization and novel ecosystems? There are two different questions in that interrogation and asking about these two strategies together will strip the answer from nuances that might be important for the validity of the research project.

Regarding the validity, the review of literature is essential for elaborating interview questions that address the relevant concepts related to the research question. It could happen that the meaning we give to certain words and concepts might not be conveyed the way we intend them to. Clarifying the meanings of the key concepts and relevant words is therefore important to avoid misinterpretation, which can also reduce the validity of my research project (Angers, 1996).

It is also important to avoid questions that might suggest a response (de Vaus, 1995; Hay, 2010). The questions aim at exploring what the informant thinks and believes, and therefore there is no good or bad answer. A possible way to avoid leading the respondent to the perceived "correct" answer is to mention the opposite positions one can hold towards the issue or topic of interest (Gauthier, 2003). The researcher should stay as neutral as possible and not express surprise or disapproval as the informant speaks. To remain neutral, I also need to consider the order of the questions which might influence the results (Gauthier, 2003, Hay, 2010). As advised by Minichiello et al. (as cited in Hay, 2010, p.107), "the most important consideration in the ordering of the questions is preserving *rapport* between you and your informant". Creating the right questions can necessitate a few trials, where the researcher will formulate different versions of the same question and then determine which one seems most appropriate (Gauthier, 2003). The researcher might want to start off the interview with easy to answer questions. It allows the informant to get used to the interview and more comfortable for subsequent questions that will require more reflection. This is not the only way to structure the interview. The questions can also be organized to first ask the easiest questions, then move on with broader and more abstract aspects of an issue, only to finish with the most sensitive questions (Hay, 2010).

When working on the questionnaire, I developed a set of primary questions and secondary questions. The former is intended to initiate the informant to a new topic, to open up a new discussion (Hay, 2010). Elaborating the questionnaire for the interview means knowing precisely what the researcher is interested in. There are distinctions to be made between behaviour, beliefs, attitudes and attributes in formulating the questions. They are separate categories and they require a specific question design to get the information of interest. Researchers would formulate a question to find out what people *do* if they were exploring behaviours, for instance. To establish

people's beliefs, the questions should be oriented towards what people think to be true or false. Questions regarding attitudes aim at finding what the informant thinks about what ought to be or not on a certain topic. The difference with questions exploring beliefs, or what the informant think is true, is that attitude questions try to establish what the informant think is desirable. The last category is attributes, and those questions aim to establish the informant's characteristics (de Vaus, 1995). Defining these categories should help the researcher to collect the right type of information. Failure to do so arises from a lack of clarity about the research question and inadequate conceptualization. On the contrary, acknowledging these categories will help the researcher to systematically develop questions according to each type. In return, this will provide some structure for the questionnaire, and help to make sure that each questions tap into the data of interest (de Vaus, 1995).

There is not a single way to conduct interviews. Every research area and topic has its own procedures that it might require for an interview. Nevertheless, there are still a few rules to guide the researchers and help them through the process, as well as assure the quality of the data collected. Lastly, as obvious as it may sound, a common mistake for interviewers is to not thoroughly know the interview content (questions) (Gauthier, 2003). The interview should be similar to a conversation in form, and that in part is the researcher's duty to clearly communicate the questions and know the interview's content thoroughly.

Before proceeding with the interviews, an evaluation in the form of a pretest is generally necessary (de Vaus, 1995, Hay, 2010). This is done in order to evaluate what is the best way to formulate a question as well as how the informants interpret the question's meaning (de Vaus, 1995). Suggestions for a pretest range from 3 to 10 people that are part of the group to be interviewed.

However, this is not as necessary for semi or unstructured interviews because the informant can give immediate feedback and I can clarify ambiguities as needed (Hay, 2010).

The guiding concepts for the elaboration of the questionnaire stem from the relevant academic literature. Themes such as the broader human-nature relation and conceptualization, conservation, adaptation and novel ecosystems are expected to emerge from the interview and unravel the participant's view of AC.

3.1.5. Semi-structured Interview

Semi-structured, open-ended interviews were favoured as the instrument of choice. This type of interview requires a guide, but it remains open to change according to the informants and what they bring to each interview. In other words, the organization of the guide remains flexible, as the researcher will still provide guidance and intervene if the conversation strays too much from the initial question (Hay, 2010). For my research project, this means having a set of questions ready to guide and structure the interviews, while allowing for the informants to re-direct some of these questions, according to what might be more relevant to them. For the full questionnaire, see Appendix 1.

3.1.6. Coding

All of the interviews have been recorded and transcribed verbatim, and then coded. The coding allows the researcher to makes sense and define the collected data, in this case the transcribed interviews. The data is carefully reviewed and then codes are attributed to pieces of text, repeating codes for similar passages and ultimately developing a framework of thematic ideas (Gibbs, 2007).

Some researchers advocate the use of a predetermined codebook prior to the data analysis, while others advocate starting without a code list and building up the codes as the analysis of the data

unfolds (Gibbs, 2007). For this research project I have proceeded mostly with the later, coding line by line with a grounded theory approach, where theories arise from the data and are supported by it. However, I also used guiding concepts found in the literature once the initial coding phase was completed. One of the challenges of coding is to move beyond the descriptive coding, and towards a more analytical and theoretical level of coding. There can also be a risk for the researcher to import her own motives into the codes and analysis. Line by line coding and in-depth analytical thinking helps the researcher to be more careful and stay close to the data (Gibbs, 2007). Analyzing data is an iterative process. I first read the whole verbatim text and made annotations and comments. I then read again, this time trying to find codes that describe and analyze the meaning of the coded excerpt. Finally, after the coding was finished, I put the codes under appropriate categories to organize and further analyze the results.

3.2. Participants

3.2.1. Sample

In qualitative studies such as this one, it is important to select participants on the basis of their experience with the explored phenomenon (Marshall & Rossman, 1995). For sampling, a list of criteria is therefore developed to select the participants with attributes and experience relevant to the topic. In many cases, it is inadvisable to identify the number of participants to include in the sample prior to field work, as the theory will most likely evolve as the data is collected and explored (Marshall & Rossman, 1995). Thus, for this research there was no predetermined sample size for data collection. Rather, what was prioritized is the professional relevance of the participants towards urban forest planning or management. For validity concerns, I hoped to recruit about 20 participants in the forest sector. The following explains in further detail the methods of participant recruitment and data collection.

I utilized purposive sampling, that is, I interviewed stakeholders that indicated their desire to participate in the project (Hay, 2010). It was my main sampling method, followed by snowball sampling, a technique where additional participants are gathered through the identification of an initial participant. I asked the interviewees to provide contact information or refer me to other relevant stakeholders. This method provides the researcher with a growing set of potential participants, taking advantage of the social network of the ability of each participant to provide the names of additional informants (Marshall & Rossman, 1995). The snowball sampling method had the potential to lead me to informants that I could not find or reach otherwise. I found that towards the end of my recruitment phase I had "saturated" the network, meaning that the same names kept recurring, which suggests that I spoke with many key people in the urban forest community in southern Ontario.

Apart from the professional relevance, the other main criteria established for sample selection was the area of work, which was restricted to southern Ontario. I explain in further details below the choice of location for the study.

Although the selected stakeholders have in common their professional activities in the management and planning of the urban forest, they are active in various organizations, including government, businesses and not-for-profit organizations. With regards to management, the urban forest is organized within a particularly complex institutional context, which can be divided into three levels. In general, forestry and parks professionals work at the first level, followed by allied professionals such as landscape architects and planners at the second level. Lastly, the third level includes developers and elected officials as well as the public (Schwab, 2009). I focused on the

first two levels to recruit participants, as they are presumably directly involved with the systemic management of the urban forest, as opposed to third level stakeholders.

In regards of the two levels of management, the professional credentials of urban foresters and arborists can be different from one individual to another. According to the International Society of Arboriculture (ISA), the difference between an arborist and a forester is the scale. Within the municipal forestry division, urban foresters, arborists and even park managers will share responsibilities for implementing the urban forestry management plan. On the other hand, urban foresters work at a larger scale and are trained to understand and analyze ecosystem functioning. Arguably, they are therefore better suited to work at the systemic level and influence tree related policies and urban forest management plans, and I thus chose to focus on them for the interviews. Table 2 shows the number of participants according to their working organization.

Table 2: Types of organization with the number of participants recruited for interviews

Type of organization	Number of participants
Business	3
Educational	1
Government	4
NGO	10

3.2.2. Recruitment

The recruitment process included several steps. I received full ethics clearance from the University of Waterloo (#19178), and then proceeded to contact potential participants. In order to recruit key informants, I relied mostly on the urban forestry network within the boundaries of southern Ontario, in particular around Toronto and the Greater Toronto Area (GTA). In the first step to recruit participants, a preliminary Internet research provided information on the various organizations active in urban forest work. I first searched the web for governmental and non-government organizations with relevance to urban forestry. I searched for the urban forestry municipal divisions of Toronto and the GTA municipalities, as well as urban forestry businesses, such as consulting enterprises. I also searched the web for ENGOs (e.g. environmental not for profit and charity organizations) that contribute to urban tree management and tree planting (if they had key programs involving tree planting, for instance). I searched urban forestry

management plans and looked for the contributing stakeholders. Some of the organizations were regional, provincial, and sometimes national. Through the contact information provided on each organization's website, I selected the individuals within these organizations that matched my criteria (work area and involvement in planning and/or management), and contacted them to request their participation. Those who showed interest and agreed to take part in the study were then interviewed in person whenever it was possible, though in a few cases by phone. I also sent an email to the Canadian Urban Forest Network mailing list, although not knowing exactly who were subscribed to that list, because I did not have access to those names. I was also able to get the names of relevant stakeholders through the snowball sampling method. At the end of each interview, I asked the participant to provide me with names and/or contact information of possible participants. This part was necessary to reach out to potential key informants that were not revealed by Internet search. For instance, local ENGOs working in small communities are absent from the literature or hard to track online, and they might not have a strong presence on social media platforms, making it harder to reach out for them. Engaging with other relevant actors of the community, such as small scale governmental agencies, could be essential to get a hold on ENGOs and their representative. Moreover, this allowed me to get to know the prevalent actors within the urban forestry sector. Getting to know the various stakeholders comprised within the sector's network was essential to make sure no key informant was left out.

3.2.3. Location

Although the location of the study was southern Ontario, not all municipalities were systematically included for the sample. Rather, I relied on the Canadian urban forest network (CAFUNET) and on the names provided through snowball sampling. The decision to focus on southern Ontario was motivated in part by the importance of the region, particularly the GTA, as well as Toronto's recent

adoption of an urban forest management plan (Toronto, 2012). In addition, The Carolinian Life Zone in southwestern Ontario stretches from Toronto to Windsor, where the highest proportion of endangered and rare species can be found in Canada (Parks Canada, 2009). Not only is southern Ontario the economic and social pillar of Ontario, but it is a region where AC might be a considered strategy to rescue vulnerable species from climate change impacts. The figure 1 below illustrates where the Carolinian Zone is in southern Ontario.

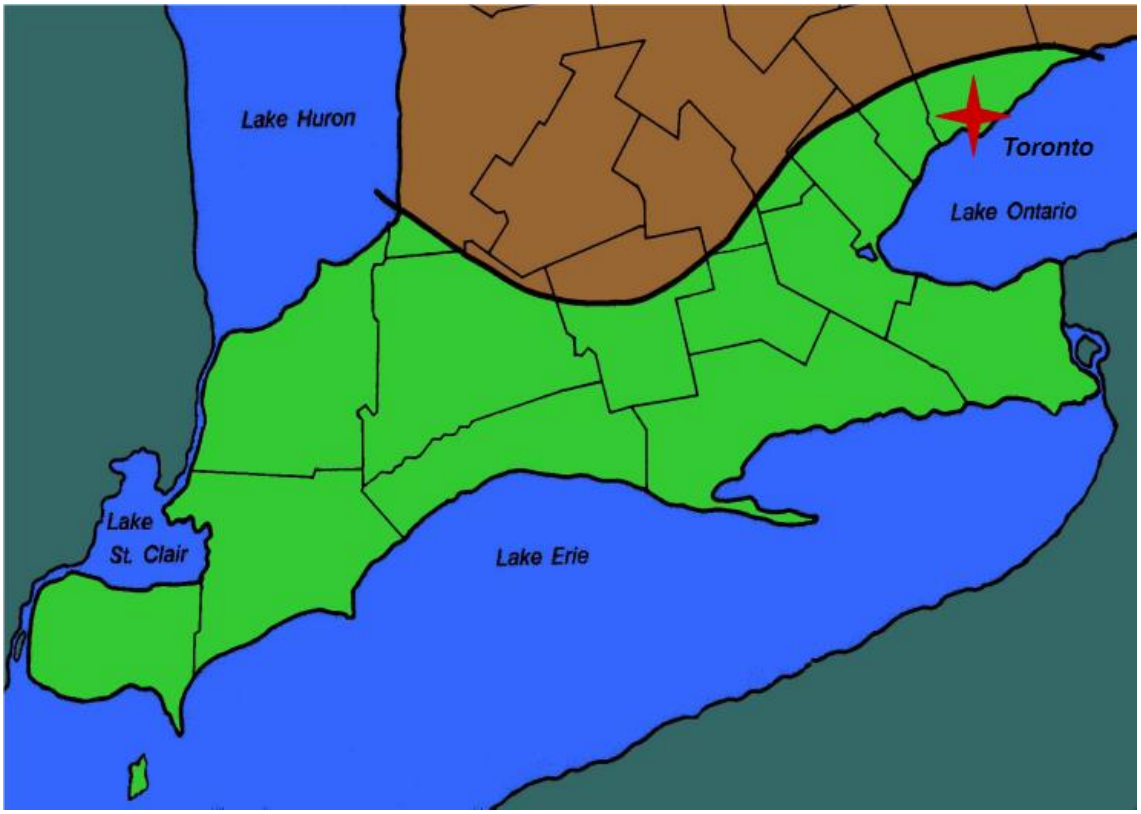

Figure 1: The Carolinian Zone in Ontario (caroliniancanada.ca)

Furthermore, to the best of my knowledge, no research on AC has been conducted in eastern Canada, while the western region has been subject to studies regarding AC and forest adaptation to climate change, presumably motivated by the economic importance of the timber industry in British Columbia (Gray & Hamann, 2013). However, one-quarter of Canada's population lives

within 160 km of Toronto, and given that climate change will impact southern Ontario's green infrastructure, there is undoubtedly value for adaptation research in the region.

3.3. Validity and Generalizability

There are possible biases that might affect the validity of this research. First, I was unable to reach some of the informants that I had myself selected for their experience and pertinence in managing the urban forest. Similarly, I was unable to reach out to a number of urban foresters who had been recommended through interviews as key informants. Secondly, those who agreed to participate could be more interested and inclined to adaptation strategies, which is a problem because it might not give a fair representation of urban foresters who are not addressing climate change. Thirdly, an unexpected extreme weather event occurred on December 22 2013, halfway through my data collection duration. The interviews took place from September 2013 until June 2014. Following the ice storm that hit southern Ontario during the winter, some of the urban foresters were constrained by an emergency response to the event and declined to participate. It proved very challenging to recruit participants, even more so from governmental organizations. Fourthly, I had great issues with the coding during the last stages. I imagined the codes to fit easily into themes and the whole data to be neatly organized. To the contrary, there were codes that did not align with themes, and the overall analysis seemed chaotic at times. Fifthly, there is a chance that participants were inclined to answer according to what they think was expected of them. This concern can be addressed to a certain extent with a skilled interviewer and a neutral questionnaire, but the possibility remains because I have little experience with interviewing. To promote more spontaneous responses, the questionnaire was not distributed prior to the interviews. To increase the validity of the research, some researchers send their transcript to their interviewees for

checking and validation. However, I did not have ethics approval for this approach, so I was unable to check back with participants to verify the analysis of their answers.

Lastly, I interviewed participants that were scattered across southern Ontario, but it must be noted that about half of my sample came from Toronto and the GTA. The extent to which my results can be generalized to the entire region of southern Ontario is therefore limited.

Chapter 4. Results

The coding of the data revealed four main categories as well as the themes that were recurrent in the respondents' answers. The categories that were revealed through analysis are consistent with the guiding concepts of the interview questions 1) species selection and underlying goals, 2) urban forestry and conservation tools 3) acceptability of AC and 4) feasibility of AC. The detailed results are presented below according to the categories and the related themes that were found. The first category is linked to the motivations behind selecting tree species for planting, and how urban foresters perceive and prioritize the different tree species. It also provides information as to where urban foresters stand towards native and exotic species for planting. This category is also linked to the underlying goals that could drive the future implementation of AC in the urban forest sector. The second category refers to the management tools used by urban foresters for their forestry and conservation objectives, such as tree inventory and monitoring. The use of these tools is conducive to the implementation of AC and other climate change adaptation strategies. Whether urban foresters have included those or not to forest management is tied to the integration of adaptation strategies in southern Ontario's urban forest sector. The acceptability of AC is a category that encompasses themes of perception towards risks, uncertainties and attitudes embedded in their management practices and AC in particular. Finally, the feasibility of AC pertains to the institutional arrangements and whether they act as barriers of enablers for current and future implementation of AC.

4.1. Species selection and underlying goals

I found in my results a pattern between the selection of species and the underlying goals of tree planting. What was prioritized first by respondents was tree establishment, which is inseparable from site conditions and species selection. Tree plantings in naturalized or harsh planting habitats

serve different goals, and are managed accordingly. Native species are strongly tied to biodiversity conservation and restoration work within the urban environment, while non-native species are tied to streetscapes and other harsh planting sites. They fulfil a particular purpose, the provision of ecosystem services and functions. The results also demonstrate that providing the maximum services to the community, and issues of genetic and species diversity were central to urban forestry and conservation goals. Although the Carolinian zone (which partly covers the region of southern Ontario) is home to many vulnerable and endangered species, conservation goals directed towards species rescue were seldom brought up by urban foresters.

4.1.1. Tree establishment

The results suggest that the prevalent objective in urban forestry planting practices is first and foremost to ensure tree establishment. Urban foresters have expressed their concerns about the challenges of bringing a tree to maturity in the urban environment. When asked about the most important dimensions to consider for selecting a tree species, the answers demonstrate that the characteristics of the urban environment at the planting site are what will drive first and foremost species selection. One respondent said on that matter that:

> Choosing it just for its function always comes after what will survive under these conditions, because planting something that does the job but doesn't survive doesn't do you any good in the long term

Many of the respondents have used this slogan to describe what defines planting practices in urban forestry: “the right tree at the right place”. This not only refers to the importance of species selection, but also to the highly fragmented habitats and the variation between site conditions that characterize the urban environment. Although growing trees to maturity was

prioritized by respondents, ultimately urban forestry aims at sustaining the provision of ecosystem services: “the whole activity of planting trees in urban settings mostly, unless it's in a ravine or natural area, is to confer benefits to the people who live among the trees”.

4.1.2. Ecosystem services

The provision and maintenance of ecosystem services were, second to tree establishment, the most important consideration in urban forest management according to the respondents. The services that were frequently mentioned are shading and temperature cooling as well as carbon sequestration. According to the respondents, despite the importance of ecosystem services provided by trees, it is a concept that has only recently been acknowledged in urban forestry:

> I would say now it's a bigger part of urban forestry, the general concept of ecosystem services provided by trees, whether they're by themselves or in a natural woodlot setting is definitely a big planning focus now. People really like to know how much carbon is being sequestered, say by a tree or a few trees

Other services that were brought up in the interviews include the less tangible wellness provided by trees, and the provision of fruits and nuts. Aesthetics services were not a priority among the respondents. A few of them did mention that urban dwellers seem to favour aesthetics and low maintenance requirement when selecting trees: “those types of considerations tend to drive people's decisions in my mind much more than an understanding of species you know, what should be there or what can be there”. Focus on aesthetics were also a potential source of conflict, as a few respondents mentioned cases where landscape architects prioritize aesthetics to the detriment of tree establishment and other services.

4.1.3. Biodiversity and resilience

The results demonstrate that biodiversity management within municipalities seemed to vary significantly from one respondent to another. According to some of the respondents, the underlying goals of both biodiversity and urban forestry are easy to conciliate. Others mentioned it is a struggle to manage for both, because of the challenges associated with urban forestry and the low priority given to biodiversity in management objectives. One respondent argued: "biodiversity, I think it's kinda taking a backseat right now, we just need our cities to work". On the contrary, others stated that balancing biodiversity and urban forestry requirements was not a problem: "they fit together quite easily [...] if you're planting natives that are suited to the site, as long as you don't plant the same ones all day every day, then you're probably serving biodiversity also". This last citation demonstrates how native species and biodiversity conservation are tied together in urban forest management.

Whether or not respondents believed urban forestry and biodiversity are goals that are easy to conciliate, they agreed to the importance of biodiversity. An important driver that was frequently mentioned was the current threat of the emerald ash borer and the impacts on urban canopy. One respondent said: "until it comes smashing through the window, literally and figuratively, until you have an ice storm, until you have an ash borer [...] the drivers of tree care are not biodiversity but costs and hazards concerns". Although respondents were associating biodiversity with native species, the threat of pests and diseases could act as a motivation for urban foresters to consider AC as a tool to maintain biodiversity.

4.1.4. Exotics vs native species

According to my results, ultimately the choice of planting native or non-native species is both tied to the planting location and to the function it serves. One respondent said: "we do sometimes plant

non-natives if they serve a particular purpose". Respondents admitted to preferring native species when selecting trees for plantings, and that using exotic species was an option in cases where natives could not survive or thrive in the site conditions. However, a nuance was also added to that position at times. Some of the respondents acknowledged that the focus on native species can be at odds with ongoing climate change:

> There is a potential for conflict there because we're being told at so many levels to stick with natives, especially for the resilience perspective and dealing with pests and that sort of thing, but you know at the same time how well are they gonna do with this changing climate and should we be introducing species from further south

This demonstrates that although the preference for native species is prevalent, urban foresters recognize that this approach might be at odds with the long-term forest planning. In addition, one respondent raised up a concern regarding the planting of native species and the lack of genetic diversity often encountered in urban forests:

> you may be planting native trees but they're all identical genetic stock, all clones, they might have been grown in the States and you know they're brought in from nurseries, and so it's one thing to say you're planting trees but if they're all clones [...] planted all on the same street, all on the same park, I'd say you know there's no difference there between planting natives or introduced species

According to the answers of a few respondents, the composition of southern Ontario's urban forest is changing as the climate becomes increasingly favourable to southern species. As one suggested: “without any kind of scientific study to back it up, they seem [trees from further south provenance] to grow a little bit faster and stronger than the ones that are more

locally sourced". Another respondent said: "sweet gum is another one and black gum are Carolinian trees that we're starting to plant, yellow wood, when I started here 30 years ago there were no yellow wood trees". The figure below illustrates the results for the theme of species selection and the underlying goals.

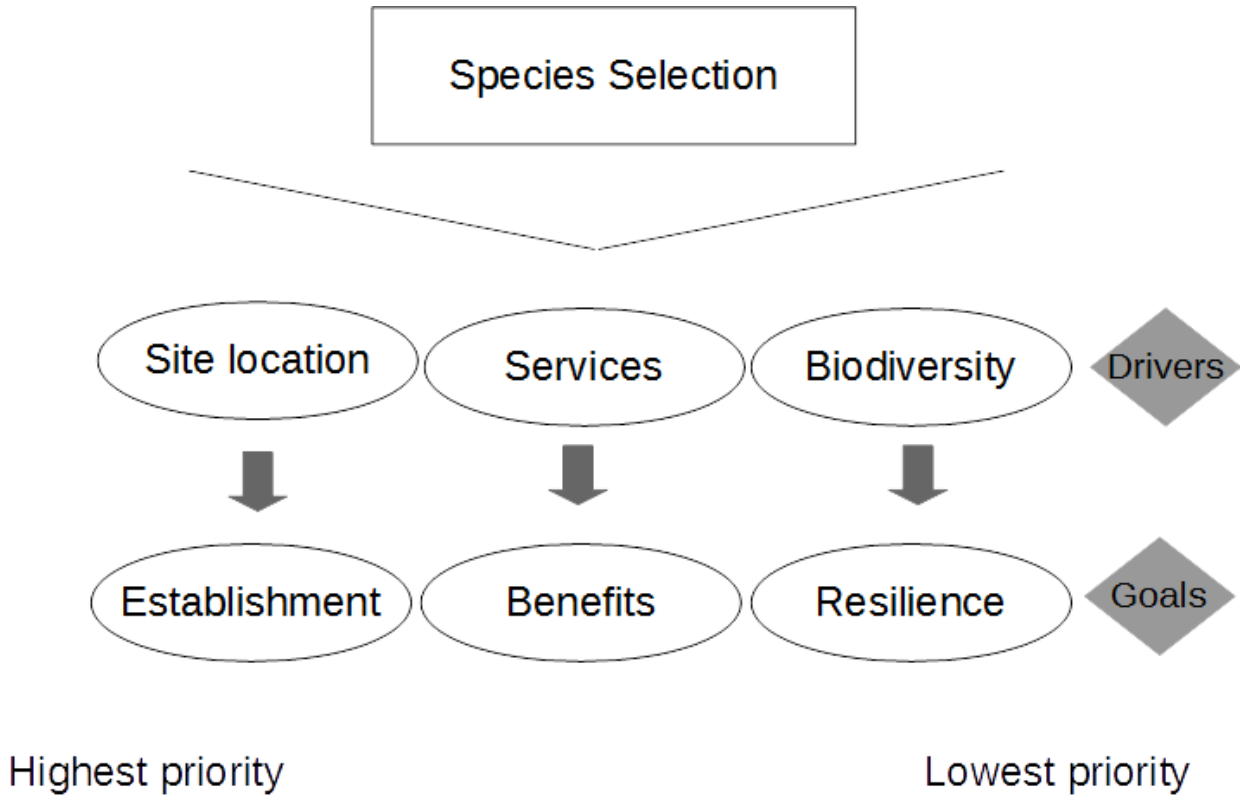

Figure 2: Results on the species selection process for plantings by urban foresters

4.2. Conservation and urban forestry tools

Findings revealed that the interviewed urban foresters still rely heavily on traditional conservation methods. They engage in restoration activities within the so-called naturalized areas (e.g.

watershed), and depend on protected areas for biodiversity conservation as well as increasing habitat connectivity. Adaptive management approach tools and/or adaptation strategies are just starting to appear in the planning and the management of the urban forest. The use of data collection techniques such as tree mapping, inventories and monitoring is uneven from one municipality to another, as well as from one organization to another. Trials with southern tree species were generally agreed upon, albeit few respondents were involved in such experiments.

4.2.1. Asset management

Asset management includes both monitoring and inventory programs. Findings were mixed on that matter. Many respondents were unaware of monitoring programs aimed at following and measuring climate impacts on native species. When respondents indeed knew about ongoing monitoring programs, they were either small scale oriented or they were not directly related to climate change. Results were similar regarding inventories. Some of the respondents, while they granted they did not do monitoring or had not heard of similar programs, seemed keen to believe that other organizations were likely to have one. One respondent said: “usually all that is done at a research from a university level and I have not heard of anything” while another one mentioned: “I can't think of any actual programs, not to say there isn't any”.

A few respondents affirmed that their own organization were actively collecting data, albeit once again it was not directly related to climate change, but could still be relevant to it: “we are doing a very comprehensive approach to monitoring, long term, with the community”. There was no evidence in findings as to why certain municipalities and other organizations are more inclined to run asset management programs than others.

4.2.2. Trials and experiments

The results demonstrate that all respondents are favourable to trials and experiments with southern tree species. On the other hand, the extent to which they are favourable to it varies from one respondent to another. Some were adopting quite a cautious stance towards it, such as insisting on the necessity to conduct those trials where the potential for propagation is low: “something to be said for these migrations maybe the first place to try these is in an urban setting so there's less you know hybridity and escape, the urban is a good testing ground”. Despite the general agreement for southern species trials, very few of the respondents had initiated or were taking part in such experiments:

> There is a group associated with I believe our local conservation authority, and they are doing experimental planting if you will with non-native species to see how well they might survive in our changing climate, so this is a group that's not directly associated with the municipality [...] the municipal focus is more to increase the number of forest cover that we have so we're sort of staying with our approved planting list.

The results suggest that the few ongoing experiments are scattered within the region, and mostly small scale. Few organizations have actually initiated those experiments, and municipalities are not directly involved in most cases.

4.2.3. Traditional conservation tools

When asked about the relevance of parks and protected areas in an era of climate change, interviewees all asserted that they remain important for ecological functions and human-nature connection. Ecosystem restoration also remains a valued conservation approach that urban

foresters still engage in. Restoration activities as well as protected areas are linked to biodiversity reserves and strongly tied to the planting of native species:

> for any of our restoration or stewardship programs, so anything that's in and around a natural area, watercourse, etc., they're all 99.9% native, so all shrubs and tree species that we plant in those areas are native, our street trees on the other hand are not [...] the tough thing is that a lot of the hardier species are not necessarily native.

Although traditional conservation tools are prevalent in urban forestry, my findings show that climate change is acknowledged as a source of change. One respondent suggested: “there's always gonna be a reserve for something. It just might not be the same thing that's there today”. Some respondents also suggested that the role of parks and reserves will become increasingly important as the world becomes more urbanized, and people will increasingly need those areas to provide a meaningful connection with nature.

4.3. Assisted colonization as an acceptable option

The perceptions towards climate threats, uncertainties, and risks pertaining to AC varied from one respondent to another. None of the respondents disagreed with the use of AC, although most adopted a prudent attitude towards it: “in concept I agree, but it needs to be done very cautiously with a lot of research”. Another said: “I would be supportive as long as there is some science to support it”. Risk assessments and science based decision making were necessary conditions that were frequently brought up while discussing AC. The risks of negative impacts as well as the cost and time frame involved in the process contribute to the lukewarm response of interviewees towards AC: “I think it could become an overly arduous process where we're trying to manage so many different elements, I would worry about the amount of money invested in any assisted

migration program". Another respondent added: "absolutely a good idea, [but] I think it's a challenge bringing the science to the practical reality of urban forestry". A few respondents seemed very favourable to AC, and did not see uncertainties and potential risks as a significant barrier to its implementation:

> moving some of them makes sense it seems to me if they'll survive and if we understand close enough how migration has happened in the past which I believe we do, why not it's bio mimickery [...] we've interrupted the pace of change so we now need to help nature follow the pace of change.

Although respondents agreed with AC in concept, the answers suggest that the current planning and management of urban forests is not set for the implementation of AC: "I don't think we're there yet, in terms of having a clear direction and where to apply it". Another urban forester said: "I don't have a problem with moving endangered species around, I think the question is why would you want to, what's the point of that [...] what is our master plan for our landscapes". The last citation seemingly refers to an ecosystem management approach that de-emphasizes species conservation, and rather focuses on the whole ecosystem and functions and services.

4.3.1. Risks, threats and uncertainties

In terms of the risks following the implementation of AC, the potential for the introduced species to become invasive was a recurrent concern among respondents. A few respondents held different attitudes towards invasiveness. Those who were the most favourable to AC, for instance, did not seem to perceive invasive species as big of a threat as other respondents. One suggested: "I don't call those invasive species, I call them the new normal, or replacement trees". Similarly, another brought up the potential to use those sturdy invasive species in areas where they cannot easily

propagate, and yet still provide services: “you know if you had really good planning we could have invasive species planted in our urban settings if they were planted in spaces where they are not a threat to invade”. The potential risks following the implementation of AC, often brought up by respondents, was a driver of the cautious position regarding AC. However, none of them disagreed with the strategy.

The unpredictability of future climate impacts, as demonstrated by the findings, was a concern among respondents. They perceived those climate-driven changes as being mostly negative for urban forests of southern Ontario, bringing up the threat of pests and droughts to illustrate their concerns. On the other hand, the perceived impacts of future species distribution varied significantly from one respondent to another. Those two citations demonstrate the extent of the variability between perceptions: “...it's not like that envelope is gonna move so far north that they're moving out of our area” as well as “our trees are gonna be stressed out [...] a lot of them are not going to survive where they currently are but are going to survive further north”. It is not clear how those perceptions will influence decision making towards AC since respondents remained altogether favourable to trials and to AC.

My findings exposed uncertainties regarding the definition of a healthy urban forest and how it applies to forestry operations: “there's a lot of forest health work being done in northern Ontario and out west etc., but not so much in an urban setting and the big question is what is healthy what is not”. The definition of what “native” stands for also seemingly varied from one respondent to another in terms of scale. For some of the respondent, the definition seemed to be broad, encompassing Ontario species, while for others the term native was restricted to local provenance “...i mean native, originally native, not native to somewhere in North America or something like

that". The perceptions of urban foresters towards those sources of uncertainties tend to vary highly from one individual to another:

> we plant native species and we plant Carolinian species, for example you know there was a time where people, the die-hard native proponents, would have said that Carolinian species like Tulip tree and Red bud and Kentucky coffee tree were not truly native here, they are at the northern edge of their range.

The concept of nativeness is ambiguous in nature, and thus it partly explains why the respondents' definitions varied when referring to native species.

4.3.2. Opportunities

A few respondents perceived the incoming climate change impacts as opportunities to improve urban forest management. Crisis, they argued, can foster awareness and ultimately improve how we manage forests by shifting attitudes. One suggested:

> Things like the ice storm help open up opportunity for discussion and so I feel the heat of this living threat at the same time it does open up an opportunity that we need to be ready to take advantage of.

Another respondent perceived the warmer climate as an opportunity for increased tree growth. One claimed that events such as the emerald ash borer has encouraged municipalities to proceed with asset management: "emerald ash borer has been one of the key things that's driven the community to say where are our ash trees anyways, then go out and start tagging and locating them". In most cases however, the findings suggest that it will be difficult for urban foresters to grab on those opportunities that might arise with climate change. As one respondent explained: "I think it's just another management consideration in an area that's already highly constrained

by budgetary, environmental and other constraints". The capacity to implement adaptation strategies will likely vary from one jurisdiction to another, according to their long-term planning and the resources they possess.

4.4. Assisted colonization as a feasible option

The results suggest that there are many barriers to the widespread implementation of AC in the urban forest sector. Respondents insisted on the shortage of staff and constrained budgets as a significant limitation to management options. In addition, the results demonstrate there is a lack of communication between organizations and stakeholders, both horizontally and vertically. The need to increase provincial and federal support to the urban forest sector was also a recurrent theme. Additionally, none of the interviewed urban foresters were aware of modifications taking effect on existing policies, or newly adopted policies to regulate the movement of seeds and species in sight of climate change.

4.4.1. Human and financial resources

Respondents mentioned the lack of resources to care for and maintain the urban forest, and how it represents an impediment to adaptation strategies. On the other hand, a few respondents affirmed their organization had the capacity to initiate trials and experiments with species, or run asset management programs, and were working on developing such programs. Some of the respondents, however, felt like adaptation strategies had yet to be integrated in the urban forest sector:

> Urban forestry is already sort of an underfunded, under recognized sort of practice [...] for the most parts, others, especially smaller communities just don't have the budget or interest to even maintain what they have, so thinking ahead of climate change is off the radar.

Altogether the results suggest that again, from one organization to another, the capacity to implement adaptation strategies and particularly AC varies significantly. One suggested that because the urban forestry sector often operates on a limited staff and budget, collaboration is crucial: “the public has to step up to the plate, the resources of the cities and so on are very limited regarding trees”. The section below expands more on this matter.

4.4.2. Policy and legislation

Respondents were unanimous regarding legislation and regulation of tree seeds and species movement. None of the interviewed foresters were aware of changes to adapt tree species movement and seed provenance to the reality of climate change. What varied was their perception on how necessary those regulations and policies are. One respondent argued that regulations might damper species trials initiatives: “...a regulation to me dulls the edge of entrepreneurship or trying different things, experimentation you know, do you need a license to experiment?” As opposed to this position, another respondent brought up the devastating effects of invasive species and called for stricter regulations of plant movements. When told about the Torreya Guardians' initiative (i.e., a private group implementing AC), one respondent who agreed with the initiative said:

> “that's the sort of things that we need to see more of [...] I think it's also the only sustainable way of dealing with, because otherwise you're looking at a process and a problem that's so intensively expensive and where the resources are so sparse, that you have a situation that's designed to fail.”

One of the respondent raised up the difficulty of applying regulations in the urban forest sector: “regulation is difficult to do in our business because every property you come to is different than

the last one so making hard rules, it comes really difficult". Regardless, findings suggest there has not been any update regarding legal matters for future implementation of AC.

4.4.3. Urban forestry practices

Urban forestry practices are influenced by nursery and horticultural practices. These can both drive or challenge the implementation of AC. The results demonstrate that nurseries have a major role regarding tree plantings as they ultimately determine planting stock and seed provenance. Interviewed urban foresters expressed concerns on the nursery industry practices, and their answers suggest that matching seed zones are not always common practice. The issue of planting local provenance seeds was also brought up in the interviews. While some respondents shared they were very diligent on planting exclusively locally sourced trees, others admitted that within the field of urban forestry, it is more often than not an ideal more than common practice: "that's the trouble because in the trade, you know you have native species coming from Ohio, in terms of trees and from Montreal, British Columbia, Oregon even". Tree nurseries, as an industry, are held accountable for that matter: "we are worried about moving species around, we're already doing it, the whole nursery industry is completely based on that". The lack of genetic diversity in nursery stock was a recurrent theme. One urban forester said:

> You may be planting native trees, but they're all identical genetic stock, all clones, they might have been grown in the states and you know they're bought from nurseries [...] I'd say there's no difference there between planting native species or introduced species.

In a few cases, respondents said their stock was local and picked up by nursery staff. The findings demonstrate that the practices vary from one municipality and the nurseries that supply them to another.

4.4.4. Governance and collaboration

The respondents often discussed how the lack of communication and collaboration within organizations and stakeholders impairs urban forest management. A few respondents said they were following bigger agencies to determine their planting strategies. Many respondents also brought up the necessity for provincial and federal governments to provide municipalities with more support and leadership, particularly regarding adaptation to climate change:

> I think a big problem there is in the urban forest governance is it's all the hands of local municipal governments already and they may not be able, they may not have the capacity to do that, you need some provincial leadership or some federal leadership and Canada doesn't have that.

All respondents agreed that the public should play an active role in the management of the forest. A large portion of the urban forest being privately owned, the public is a significant stakeholder. Informants on that matter were unanimous: “it’s really a joint responsibility”, “in many cases it’s the citizens’ interests and passions that end up driving policies so there is always gonna be a very large role for society there”. The need for education regarding tree value and management, stewardship, as well as reconnecting with nature were the main expressed concerns regarding the public's role towards urban forests. The public’s engagement in the not-for-profit sector, as well as the professionals working in that sector also weigh in considerably regarding tree planting activities. As stated by one respondent:

> I know for our city the voluntary sector plants more trees than the developers and the city put together, so if you wanna talk about who is planting the urban forest, it's the voluntary

sector, the city is obviously a partner there, but physically it is volunteers that are doing that.

A few respondents shared that interactive tools have been set up in certain municipalities. The goal is two-fold: to encourage the active participation of the public to the management of the urban forest, and to decrease the burden on municipal agents.

4.5. Summary of findings

- The selection of species is tied to the pursued objectives and native species remain strongly favoured for tree plantings

- Adaptation to climate change tools such as monitoring and species trials are scarce and scattered among municipalities and organizations

- Urban foresters are seemingly favourable to a constrained implementation of AC, informed by science and risk assessments

- The lack of provincial and federal support will most likely delay extensive implementation of AC and related policies

Table 3: A summary of the state of assisted colonization in the urban forest sector of south Ontario

Assisted colonization in the urban forestry sector	
Where	Downtown core, streetscapes and boulevards
Why	To sustain and maximize ecosystem services
What	Assisted range expansion of Carolinian species
Who	Forest stakeholders from government and nongovernment organizations

Chapter 5. Implications and recommendations

The research question of this study was: How are urban forest stakeholders of southern Ontario thinking of adaptation strategies such as assisted colonization in urban forest planning and management? I aimed at finding out the following objectives:

1. Assess southern Ontario urban foresters' knowledge of AC;
2. Determine if urban foresters are favourable (or not) towards AC;
3. Explore urban foresters' attitudes related to AC and other novel conservation tools and goals;
4. Explore the extent to which urban foresters are integrating adaptation strategies in their planning and management;
5. Provide meaningful information for future AC policy-making and for moving forward with climate change adaptation strategies in southern Ontario.

The purpose of this research was to add the voice of key stakeholders to the ongoing debate about AC. By exploring the perceptions of southern Ontario's urban foresters towards this strategy, this research filled a knowledge gap regarding both AC and adaptation strategies applied to the urban forest sector. Most of the findings are consistent with previous studies on urban forestry and with AC literature. With this research, I was able to explore how these two assemble.

5.1. General observations

The results demonstrate that although urban foresters are generally aware of AC as a strategy for climate change adaptation, it remains so far a theoretical concept more than a management tool. Urban foresters are not currently planning on implementing AC in the urban forest sector. Even

though there is a broad awareness of this strategy as a potential tool, there is no initiative to encourage widespread implementation of AC to enhance biodiversity, to provide services or to rescue vulnerable species. As opposed to the extensive trials in British Columbia, and how the Canadian forestry industry is preparing for future use of AC, the urban forest sector has no coordinated plan of action. On the other hand, urban foresters do agree with the concept of AC, under cautious review. Critical events, such as the emerald ash borer infestation and the 2013 ice storm are drivers of change, and might encourage urban foresters to resort to adaptation strategies such as AC, for instance to sustain canopy cover. The delineation between what falls towards adaptation and regular management can sometimes be blurry. Current strategies used by municipalities who are dealing with the emerald ash borer could be qualified as adaptation. What is clear, however, is that adaptation to climate change is not a priority goal in urban forestry. This is in part explained by the resource constraints in the urban forest sector, and a lack of guidance from government agencies and collaboration between stakeholders.

5.2. What place for assisted colonization in urban forestry?

Using McLachlan's framework (2007), the interviewed urban foresters could be perceived as proponents of a constrained use of AC. Although there is a wide range of attitudes and stance that fall in this position, proponents believe that translocations should be firstly informed by scientific information and expertise (McLachlan et al., 2007). To alleviate the risks, experts must proceed with careful assessments, and run data collection programs throughout all stages of the AC procedure. However, as the results demonstrate, there are seemingly few ongoing monitoring programs aimed at climate change impacts. On the other hand, municipalities have expressed their willingness to run comprehensive inventory programs, as demonstrated by a review of urban forest management plans (Ordóñez & Duinker, 2013). Still, few respondents were themselves directly

involved in broader monitoring programs and inventories, and the overall results suggest that data collection programs are not widespread in southern Ontario's urban forests. The literature is very clear about the need for urban foresters to conduct resource inventories and monitoring. Conducting localized inventory and monitoring is a step towards adaptation, but comprehensive and ongoing data collection allow urban foresters to detect problems early on and manage proactively (Savard et al., 2000; Alvey, 2006; Dietz et al., 2003; Barker & Kenney, 2012). It also makes it easier to set management goals and clearly identify objectives.

The results point out to unequal use of such tools, and of the information gathered. Conway & Urbani (2007) had already come to similar results in a previous study, affirming that few municipalities had planned monitoring programs or ongoing ones. Still, urban foresters are seemingly in favour of a constrained application of AC, where decisions regarding AC are taken based on substantial data gathered in asset management programs (McLachlan et al., 2007). Following this constrained approach, AC is unlikely to be widely implemented in the urban forest sector. Constraints are reputedly challenging regular management objectives such as tree maintenance (e.g. pruning), and therefore AC might only be an option for a few species of high concern. Forestry AC, on the other hand, might already be implemented by urban foresters without officially referring to it as AC.

The findings on planting practices show that “unofficial” AC could indeed be perceived as being well underway in southern Ontario's urban forests. Assisted population expansion, as previously explained, is a type of AC that is less risky and contentious, and where the translocation of a population does not exceed the species' range (Leech et al., 2011; Winder et al., 2011). My findings have shown that urban foresters are planting Carolinian species, which may or may not be considered native, according to the operational definition given to nativeness. Notably, tree species

that were at times cited as being the least native and exotics figure in the Ministry of Natural Resources list of Ontario's native species (e.g. Tulip tree, Kentucky coffee tree) (MNR, 2014). Regan et al. (2002) use the term "theoretical indeterminacy" to describe uncertainty that stems from the ambiguity around the usage of a conceptual term. In this case, the scale represented by the term native changed between respondents. Thus, assisted population expansion can be considered widely implemented, with southern Carolinian tree species being planted at the northern edge of their range, mostly for the services they provide. The plantings of Kentucky Coffee tree in Toronto has been mentioned in the literature as an example of species that are being selected in anticipation of warmer climate (Agrell, 2011).

Notably, it could be argued that assisted range expansion is AC nonetheless, and accordingly the findings of this research demonstrate that AC is being implemented to maintain canopy cover and ecosystem services. The forestry industry has coined the term assisted range expansion, which is seldom used in the literature aimed at AC for conservation purposes. My findings and the literature on AC so far demonstrate somewhat of a tension between AC and how its implementation is justified. While urban foresters seem to hesitate when it comes to AC for biodiversity conservation purposes, they are not as reluctant if AC is to be used for the provision of ecosystem services.

5.3. Motivations for assisted colonization

The findings have shown that biodiversity and native species are strongly tied together. In the light of those results, in the near future AC is unlikely to be implemented in order to maintain or enhance biodiversity. In the literature, it has been suggested that AC could be a potential option to contribute to restoration projects, as the goals of ecosystem restoration are challenged by rapid climate change (Park & Talbot, 2012). Rather than attempting to recreate historic conditions, ecologists and urban foresters could plan on establishing ecosystems with determined functions

and consider novel species assemblages (Harris et al., 2006). As the findings demonstrate, urban foresters remain reluctant to introducing species in those naturalized areas where restoration projects take place. So far, the current assisted population expansion is being used to sustain ecosystem services in areas where native trees are not adapted, and their health and growth are not optimal or may be compromised. Lunt et al. (2013) have used the term *pull assisted colonization* to illustrate such cases of AC. Pull AC means that recipient sites are identified and selected species are 'pulled' into the recipient site to provide ecosystem services. In line with findings from previous research (Bolund & Hunammar, 1999; Konijnendijk et al., 2006), the provision of services and the value of those services are becoming increasingly important in urban forest management. While AC is seemingly set to be implemented solely for the provision of ecosystem services, it could also contribute to street tree diversity. Because of the emerald ash borer and the impact the pest will have on urban canopy, as well as increase drought, urban foresters might have to increasingly rely on resistant species from the south. Reviewing the municipality's approved planting lists would at the very least contribute to the adaptation of the urban forests for long term planning.

In regards of threatened species, their protection seemingly falls outside the scope of urban foresters' operations, and results suggest they might not implement species rescue AC on their own initiative. Organizations specialized in species conservation might be in a better position to perform species rescue AC. However, running inventories and monitoring in order to find which species are most vulnerable would provide valuable information to conservation organizations in charge of rescuing threatened species. In collaboration with conservation organizations, mapping potential recipient sites and species as risk would further contribute to a proactive approach and prepare for future implementation of species rescue AC.

5.4. Selection of the site and the species

Regulations and legislations aimed at seed sources and species movement are seemingly not an impediment to the selection of the planting site and the provenance of tree species. Foresters have used the concept of local seed source guidelines for their plantings because they are best adapted to local conditions, but they are not suited to the reality of climate change (Williams & Dumroese, 2013). However, my research findings suggest that right now those guidelines are loosely being followed in the urban forest sector. A large proportion of plant species are planted well outside of their range for ornamental purposes in horticulture, and this practice could very well extend to urban forestry for other services (Woodall et al., 2010) Late adoption of new or updated regulation systems might remain unnoticed on an operational level, since 1) nurseries ultimately decide stock provenance and availability 2) horticulture practices are embedded in the movement of exotic species, and 3) the planting conditions of urban areas greatly influences the species to be planted. My findings suggest that urban foresters, through their experience and experiments, could actually be contributing to policy development rather than implementing it. Further research is required to determine if bottom up policy development emerging from urban forestry groundwork is possible, in particular for future implementation of AC.

Regarding species selection, going forward with AC will require urban foresters to review their management practices at times. The preference for native species and local provenance will be increasingly at odds with the changing climate and current conservation goals. As Ste-Marie et al. (2011) have suggested, AC requires paradigms and management practices to be revisited. Although respondents were reluctant to associate biodiversity with the introduction of population/species, maintaining biodiversity with AC should be considered an option. Urban

foresters could alleviate the rampant problem of low genetic diversity by first moving selected populations of tree species within range (Aubin et al., 2011).

5.5. Recommended actions

While a few municipalities of southern Ontario recommend the adoption of the adaptive management approach in their UFMP, no plans have applied its principles to address prevailing uncertainties (Ordóñez, Duinker, 2013). In line with previous research on resource management, although plans recommend an approach based on adaptive management, few actually implement it (Lawler, 2009). Without specifically relying on adaptive management to facilitate AC decision making and implementation, some of my recommendations still draw from certain aspects of this management approach. My recommendations to help the sector of urban forestry move on with AC decision-making and implementation are the inclusion of local and non-expert knowledge, improving knowledge sharing, as well as promoting institutional flexibility and leadership.

5.5.1. Definition of key concepts

The findings have revealed a general uncertainty on key dimensions that pertain to both urban forestry and to AC. Park & Talbot (2012) have described intractable uncertainties such as tree climate adaptation or future climate sensitivity as significant knowledge barriers. Nevertheless, I believe that moving towards a concerted and widespread implementation of AC requires a clear and shared definition of certain key concepts, to alleviate conceptual uncertainties when it is possible, as different understandings could impact management practices and planning. Applying some of the principles of adaptive management will help urban foresters address intractable uncertainties such as future climate impacts and tree climate adaptation.

1) Urban forest health: Some of the respondents raised up concerns about ensuring the health of the urban forest, while acknowledging there is operational uncertainty as to what is considered healthy exactly. There are characteristics in the composition and structure of the urban forest that are associated with a healthier urban forest, but setting up defined goals and objectives can be challenging. Although AC has the potential to preserve urban forest health, the lack of a clear definition to guide operations could delay decision making. Urban foresters need to know how exactly urban forests could benefit from AC to integrate it to their management. Vulnerability assessment could be a valuable contribution to determine which species are most vulnerable and allow early action to be taken to maintain forest health (Ste-Marie et al., 2011). Urban foresters mostly work with canopy cover targets, but developing a set of criteria and indicators would further help managers improve tree health (Kenney et al., 2011).

2) Nativeness: There needs to be a common understanding among urban forest stakeholders on the concept of nativeness. I found in the results that definitions of native species tended to vary, and that according to the operating scale, AC was a management strategy already implemented in southern Ontario. A regulated and widespread use of AC will necessitate a shared definition of the scale that defines nativeness. A clear definition will also allow a uniformed implementation of AC, and facilitate common understandings from communications and knowledge sharing between stakeholders. Seed source and tree species selection, and consequently tree planting management, is likely influenced by an urban forester's perspective of what falls in the native category and what does not. However, nativeness can be perceived as an ambiguous concept. Ambiguity is a type of uncertainty where multiple valid and sometimes conflicting ways of framing an issue coexist (Brugnach

et al., 2008). From there, different stakeholders will hold different meanings, and rather than coming to terms with one definition, the ambiguity could prevent a common understanding. Nevertheless, there are strategies to deal with ambiguity (Brugnach et al., 2011).

3) Varying forms of AC: Similarly to the definition of native species that prevails from one respondent to another, explicitly defining AC and then distinguishing the types of AC is a necessity for future decision making regarding AC. The urban foresters with a "looser" definition of nativeness were the ones that seemed to be unknowingly implementing assisted population expansion. I believe that with a common understanding on what defines AC and its sub forms, and what the strategy entails, it would be easier to map out where and what kind of AC initiatives are currently taking place in southern Ontario's urban forests. Providing a definition of AC and how it can be used could also dispense urban foresters with management tools that they might not be aware of, and assist them in their tree species selection process.

One way to ease the integration of climate change adaptation strategies within urban forest management pertains to how the issue is framed. A research project regarding planning and climate change policies in the regional municipality of Waterloo, Ontario, has shown that although planning documents take climate change into account, economic considerations are generally prioritized at the decision-making level (Shireen, 2013). My research findings demonstrate that AC is already being implemented on the grounds of providing ecosystem services to urban dwellers: reframing the concept of AC away from climate change adaptation and closer to ecosystem services and their monetary value might contribute to the widespread implementation of AC, as it has been done in the forestry sector. One major implication, however, is the ethical considerations regarding the drivers of AC. Species that are more economically valuable might retain funding to pursue AC, to the detriment of vulnerable species. Rescuing vulnerable species

could require resource managers to necessarily frame the issue in terms of monetary value and services or function provided. Putting climate change adaptation into context and framing climate change policies in a more enticing way might nevertheless contribute to increasing their appeal to decision-makers.

5.3.2. Need for leadership

The findings have shown that in some cases, a few respondents did not feel confident on the science enough to proceed with plantings of southern species, or they claimed their organization did not have the capacity to run experiments or proceed with AC. A way to overcome such obstacles is to form partnerships and rely on actors that offer leadership. Institutional leaders participate in shaping change and innovation, and they play a defining role for the success of partnerships (Folke et al., 2005). Those leaders can help manage conflicts, make connections between stakeholders and organizations, contribute to building a vision for the community, and mobilize support among other benefits (Folke et al., 2005). I suggest the creation of a working group dedicated to AC in southern Ontario's urban forests. This group could combine a wide range of urban forest stakeholders, and provide the leadership that is currently missing to help AC and broader adaptation strategies move forward with widespread implementation in the sector.

5.3.3. Need for collaboration

Implementing AC in an environment with highly fragmented habitat and ownership will require problem-solving through partnerships and collaboration, and what can be coined as co-management. Folke et al. (2005) describe it as "collaboration of a diverse set of stakeholders, operating at different levels, and often through networks from local users to municipalities, to regional and national organizations" (p.448). There will be collaboration within and outside municipal jurisdictions, because the implementation of AC will inevitably cross borders. However,

collaboration in urban forestry also implies the broader public's participation. All respondents agreed that the public should play an active role in the management of the forest. A large portion of the urban forest being privately owned, the public is a significant stakeholder. To increase the acceptability and feasibility of AC initiatives, urban foresters, NGOs and businesses should collaborate with the public. Public opinion is indeed expected to significantly contribute to the planning and decision making of AC (Park & Talbot, 2012). With the importance of the public in urban forestry management, not only their direct contribution is essential, but public opinion can also influence management and the implementation of AC. Surveys that address the future of urban forestry under climate change and AC should be considered for future planning, as public opinion could ultimately determine on which terms AC is applied, if it is (Park & Talbot, 2012).

Initial consultations to inform and get the public's consent and public participation could facilitate the species' translocation and increase the chances for successful establishment. Site location and conditions within the urban environment are a major determinant in tree planting, and private lands could potentially be used as planting sites: "residential areas is where the ground is to plant, not in the downtown core, and the parks have a lot of trees already". In addition, the public's collaboration could help with inventory and monitoring tasks to measure both climate change impacts and evaluate translocation initiatives. Documenting and sharing the undergoing trials and experiments across the region is a step towards the wider implementation of AC. Sharing detailed information of site location and condition, the species that are planted and their provenance, as well as the time frame and all of the actors involved in the test plots through funding, planting, monitoring, and evaluating will contribute to broader AC research (Williams & Dumroese, 2013). To do so, urban foresters should seek collaboration with both experts and non-experts. Indeed, scientists

recommend the inclusion of amateur ecologists and local forms of knowledge as resources to address complex issues (Francis et al., 2012; Berkes, 2009).

5.3.4. Need for coordinated action

To ensure a more coordinated approach to urban forestry across Ontario, there has been suggestions to adopt a national plan of action (Barker & Kenney, 2012). Smaller municipalities and organizations often have fewer resources to conduct data collection programs that include systematic inventory and monitoring, even though they are just as vulnerable to urban forestry challenges as large urban centres (Barker & Kenney, 2012). A national strategy for urban forests would provide some guidance to those smaller municipalities and would contribute to even out management across the province (Barker & Kenney, 2012).

The findings have shown a favourable response to the example of the Torreya Guardians, the private group responsible for the translocation of the Torreya from Florida to North Carolina (Schwartz et al., 2012). The case of the Torreya Guardians has been used at times in the literature as a call to regulate AC led by private groups (McLachlan, 2007). However, if governmental agencies do not come up with updated policies or review their seed zone guidelines, these types of initiatives could escalate. Where private groups and citizens will not be constrained by law, and where governments will fail to take actions, ENGOs and others could be motivated to undertake AC on their terms. This issue goes back to one of the key ethical question in the overall AC debate, as to who has the right, who can assist the movement of species (Minteer & Collins, 2010; Schwartz et al., 2012).

Chapter 6. Conclusion

Through my research, I aimed to determine whether urban foresters in southern Ontario are favourable to assisted colonization, and on which terms. I proceeded with semi-structured, open ended interviews where urban foresters from a variety of organizations and background shared their thoughts and their management practices with me. Are they monitoring to see how native species are coping with the changing climate? Are they conducting trials and experiments within new ranges or with new species? After transcribing the recorded interviews into verbatim, I proceeded to coding with a grounded theory approach while still using existing concepts to guide my analysis.

The findings demonstrate that although respondents are generally favourable to assisted colonization, it is not currently being integrated to urban forest planning and management. Respondents were mostly favourable to a constrained use of assisted colonization, meaning it should be primarily implemented by experts, on the grounds of scientific information. Accordingly, decision making should be taken on the basis of substantial data, with careful risk assessments and monitoring throughout each step of the translocation. Respondents expressed concerns and at times divergent views towards climate uncertainty. The risks of negative impacts following the translocation, in particular invasiveness, were frequently brought up.

Notably, “unofficial” assisted colonization in the form of assisted population expansion is well underway in southern Ontario's urban forests. Indeed, urban foresters I interviewed are already planting southern tree species at the northern edge of their range. My findings also suggest a pattern between the selection of species and the purpose of that species. For instance, exotic species are strongly tied to their function, and seem to often be the replacement option when the growing conditions are not favourable to native species. Native species on the other hand are tied to

biodiversity conservation and naturalized areas. I believe that these findings suggest a preference for assisted colonization for the purpose of sustaining ecosystem services. Restoration and preservation are still prevalent conservation strategies within urban naturalized areas, and respondents were reluctant to introduce species and to resort to assisted colonization in those areas.

Overall, adaptation strategies are slowly being integrated to the planning and management of the urban forest, but it remains a future project more than an ongoing one. Still, the delineation between what falls towards adaptation and regular management can sometimes be blurry, and the response of municipalities to threats such as the emerald ash borer can be considered as adaptation. A proactive and innovative approach has been deemed necessary to deal with the magnitude of climate change, but my findings suggest that urban forestry is being managed reactively. Municipalities are seemingly very constrained by their limited financial and human resources, as well as the characteristics of urban planting environments. To move forward with decision making regarding the extensive use of assisted colonization, urban foresters will require strong leadership from higher level governance agencies. All municipalities should adopt and implement an urban forest management plan, under the guidance of a provincial urban forestry program, and run asset management programs.

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APPENDIX 1 – INTERVIEW QUESTIONNAIRE

Warm up

· What do you do as part of your work in this organization?

· From your experience, what do you think is the biggest challenge in the field of conservation and restoration?

· How do you think climate change will be impacting ecosystem services provided by the urban forest?

· In your work experience, what place does cc adaptation currently hold in the management of the urban forest?

Goals

· What are the most important dimensions to consider when planting trees in urban settings?

· Do you plant both native and non-native species?

    O What is the balance?

    O How does that fit in with the integration of climate change adaptation strategies in urban forest planning?

· How can you manage biodiversity conservation with the specific requirements of urban forestry?

Tools

· How do you go about the provenance of seeds in nurseries when choosing trees to plant? Have there been changes in the seed source selection?

· What do you think of trials or experiments with southern tree species in the urban area?

O Do you believe your organization has the capacity to initiate or help with such experiments?

· Is there an ongoing monitoring program to see how native species are affected by the changing climate?

O If not, why not?

O If there is, can you tell me more about it

· Are you aware if there has been changes in the policies that regulate the movement of seeds and tree species?

O Which changes?

O Do you believe it should be regulated?

· What do you think of moving a possibly endangered species, animal or plant, up north because it's going to do well with climate change?

Conclusion

· What role should the public play in regards of caring and managing the urban forest?

· Do you know anyone who would be interested in participating in my research project?